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(1) REPORT of Maj. J. D. Miley, U. S. Volunteers, first lieutenant, Second Artillery, on operations in the Department of California, 3783; (2) report of Lieut. John B. Bennet, Seventh Infantry, on operations in the Department of the Columbia, 3784.

LAWS AFFECTING THE CORPS OF ENGINEERS, FIFTY-FIFTH CONGRESS, SECOND SESSION, 1897-98 3789

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX J J.

IMPROVEMENT OF CHICAGO AND CALUMET HARBORS AND CHICAGO AND ILLINOIS RIVERS, ILLINOIS, AND CALUMET RIVER, ILLINOIS AND INDIANA; ILLINOIS AND MISSISSIPPI CANAL.

REPORT OF MAJ. W. L. MARSHALL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Chicago Harbor, Illinois.
2. Chicago River, Illinois.
3. Calumet Harbor, Illinois.
4. Calumet River, Illinois and Indiana.
5. Illinois River, Illinois.
6. Operating and care of Lagrange and Kampsville locks and dams, Illinois River.
7. Illinois and Mississippi Canal.
8. Operating and care of Illinois and Mississippi Canal. (Canal around lower rapids of Rock River, Illinois.)

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 22, 1898.

GENERAL: I have the honor to transmit herewith annual reports upon the works in my charge for the fiscal year ending June 30, 1898, as follows:

* * * * * * *

Very respectfully, your obedient servant,

W. L. MARSHALL,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

J J 1.

IMPROVEMENT OF CHICAGO HARBOR, ILLINOIS.

The project for this harbor was adopted in 1870 and modified in 1878. By act of July 3, 1896, the project was again modified to include dredging Chicago River, of the inner harbor, to admit passage by vessels drawing 16 feet of water.

The project of 1870, as modified in 1878, contemplated—

(*a*) The formation of an outer harbor or basin by inclosing a portion of Lake Michigan just south of and adjoining the entrance to the river

for the purpose of increasing the harbor facilities of Chicago and to give relief to the overcrowded river.

(*b*) The construction of an exterior breakwater of crib work filled with stone in deep water in Lake Michigan and wholly detached from the shore, north of the entrance to Chicago River, to shelter the entrance to the river and the outer harbor from northerly storms and to form a harbor of refuge at the southern end of Lake Michigan. The project also included the maintenance by dredging of the channel at the entrance to Chicago River as far west as to Pine street, and the piers so far as they project beyond the existing shore line. All of this project has been completed except dredging the outer harbor.

(*c*) Under the river and harbor act of June 3, 1896, the Chicago River, which is the inner harbor, has been directed improved for vessels drawing 16 feet of water. This work is reported upon separately as "Improving Chicago River, Illinois."

CONDITION OF THE WORK JUNE 30, 1898.

Outer basin.—This basin originally covered 455 acres of the area of Lake Michigan, of which 270 acres lie seaward of the dock line established by the Secretary of War September 22, 1890, and 185 acres west of this dock line. The dock line is about 1,300 feet east of the right of way of the Illinois Central Railroad and 2,000 feet distant from, and parallel to, the easterly breakwater of the basin.

A portion of the outer basin was dredged prior to 1887 to a depth of 16 feet, by the United States, but work was suspended due to the litigation over the ownership of the submerged lands and because the harbor was not and could not be used for its intended purposes.

The basin beyond the dock line is gradually filling up with sand and sediment, until its available depth does not exceed from 12 to 13 feet.

The litigation is now practically ended so far as the ownership of lands is concerned, and it would be well to dredge this basin to 20 feet depth.

Under authority granted by the Secretary of War July 24, 1895, a bulkhead has been constructed along the dock line, and the area shoreward of the dock line is now being filled in for a public park.

At the northern end of the basin are several slips and docks now in possession of the Illinois Central Railroad Company, but title is in litigation. In view of the restricted capacity of Chicago River these outer slips and docks become more important to the commerce of the city, and the wisdom of dredging the outer basin to 20 feet depth becomes apparent. The northern part is now in use for commercial purposes, and the entire basin would be useful as a safe roadstead for large vessels if dredged. The cost of this dredging is estimated at $452,826.

The piers of this basin are now in good condition.

No work has been done during the year by the United States Government in this basin nor on the breakwater limiting it.

EXTERIOR BREAKWATER.

This work is situated about 1 mile north of the entrance to Chicago River, which it shelters against northerly storms. The breakwater is 5,413 feet in length, 30 feet wide, and constructed in water varying from 18 to 32 feet in depth. All of it, except 1,200 linear feet, which is on a foundation of riprap stone, has been built upon the natural sand and clay bottom.

This work has been successful and well subserves its object. It was begun in 1880 and completed in 1890. This breakwater has been slightly damaged by a vessel running into it, but otherwise is in good condition. No work has been done upon it during the year and probably none will be required for several years.

ENTRANCE TO CHICAGO RIVER.

It has been customary for the United States to maintain the channel between the piers and docks at the entrance of Chicago River by dredging to the extent required by vessels of the dimensions navigating Chicago River as far as to Rush Street Bridge, and the improvement of Chicago Harbor has been limited inshore by this bridge.

During the past fiscal year no work has been done at the entrance to Chicago River. A bar is forming just south of the entrance which requires about 15,000 cubic yards dredging.

There have been several collisions during the year, named in the report of Asst. Engineer G. A. M. Liljencrantz hereto attached, by which the piers at the entrance of the harbor have been damaged. Requests have been made by the officer in charge upon the owners of the colliding vessels to repair the same, and the requests have been acceded to and the repairs made, or arrangements made to repair such injuries without expense to the United States, as indicated by the engineer in charge of the harbor.

PROPOSED APPLICATION OF FUNDS NOW ON HAND.

It is proposed to apply the funds on hand to the maintenance of existing work.

Appropriations.

By act of—	
July 11, 1870	$100,000.00
March 3, 1871	100,000.00
June 10, 1872	90,000.00
March 3, 1873	90,000.00
June 23, 1874	75,000.00
March 3, 1875	78,000.00
August 3, 1876	5,000.00
June 18, 1878	75,000.00
March 3, 1879	75,000.00
June 14, 1880	145,000.00
March 3, 1881	150,000.00
August 2, 1882	200,000.00
July 5, 1884	100,000.00
August 5, 1886	75,000.00
August 11, 1888	200,000.00
September 19, 1890	100,000.00
July, 13 1892	72,000.00
August 18, 1894	80,000.00
Total appropriated	1,810,000.00
Received from all other sources since 1870 (transfer of tug, sales, etc.).	630.16
Total	1,810,630.16
Expenditures to June 30, 1898	1,801,233.96
Balance unexpended June 30, 1898	9,396.20

Money statement.

July 1, 1897, balance unexpended	$10,058.39
June 30, 1898, amount expended during fiscal year	662.19
July 1, 1898, balance unexpended	9,396.20

COMMERCIAL STATISTICS.

Amount of revenue collected during fiscal year 1898, $4,179,879.94.

Arrivals and clearances of vessels, Chicago Harbor.

	Arrived.		Cleared.	
	Number.	Tons.	Number.	Tons.
Steam	6,013	5,004,385	6,068	5,061,251
Sail	1,816	634,020	1,823	664,567
Total	7,829	5,638,405	7,891	5,725,818

Receipts and shipments by lake at Chicago, during calendar year 1897.

Receipts.	Tons.	Shipments.	Tons.
Coal	1,044,224	Flour	151,798
Iron, iron ore, and nails	104,876	Grain	2,425,879
Fish	2,149	Lead	122,086
Lumber, wood, etc	1,988,285	Lard	23,450
Flour, salt, sugar, and sirup	323,386	Meats	3,472
Cement, plaster, etc	123,036	Sugar and sirup	48,852
Potatoes	30,290	Coffee and tea	2,612
Green fruit	34,245	Steel rails	150
Coffee and tea	8,187	Iron and nails	9,818
Grain	109,670	Hay	4,256
Liquors	6,930	Coal	631
Oil and paint	7,094	Oil and oil cake	28,120
Peas	10,148	Miscellaneous merchandise	225,058
Miscellaneous merchandise	311,057		
Total	4,103,577	Total	3,046,182

Comparisons of receipts and shipments for five calendar years, 1893, 1894, 1895, 1896, and 1897.

Year.	Tons.
1893	7,958,963
1894	7,209,236
1895	7,205,942
1896	6,347,163
1897	7,149,759

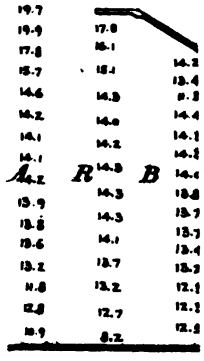
REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

CHICAGO, ILL., *July 1, 1898.*

MAJOR: I have the honor to submit herewith a report on operations in Chicago Harbor, Illinois, during the fiscal year ending June 30, 1898.

There was no contract in force during the year for any work of improvement in this harbor, and no work was done by the United States Government.

Several mishaps occurred to the works during the past year by way of vessels running into the different breakwaters and piers, doing more or less damage to these. In the middle of the month of August, 1897, the steamer *Lorain L*, of Chicago, ran into the southerly breakwater, but the damage done was not such as to require repairs. On the 28th of the same month the passenger steamer *City of Racine*, of the Goodrich Line, Chicago, ran into the east face of the north portion of the easterly breakwater, doing considerable damage. Not less than twelve courses of the side timbers were broken to pieces. The damage was repaired by the vessel owners, and this work was inspected and accepted on the 27th of September following. On the 21st of this same month the steamer *City of Fremont*, of the Hurson Transportation Company, ran into the southwest corner of the North Pier, breaking the side timbers in all of the eight courses of the superstructure. This damage was repaired by the placing of half-inch thick plates of boiler iron around the corner,



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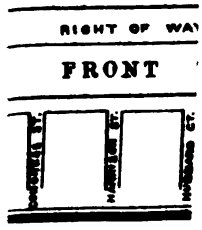
OF BEING FILLED.



the said plates being secured to the work by screw bolts passing through the side timbers and into uprights inside of the wall. The work of repairs was inspected and approved on the 8th of November, 1897.

On the 17th of April the steamer *Simon J. Murphy*, of Greenbay, Wis., ran into the south face of the North Pier about 260 feet from the east end, breaking the side timbers of the ten upper courses on that side of the pier and even some on the opposite or north side of it. The owners of the vessel caused the damage to be repaired, which work was inspected and approved on the 17th of June last.

On the 28th of May the steamer *German* ran into the South Pier at a point about 500 feet west af the U. S. Life Saving Station and did some damage, though slight, to the top timbers. On the 27th of June the whaleback *Christopher Columbus* ran into the same pier about 100 feet east of the place last referred to and broke the top side timber. Both the damages just alluded to have now been repaired.

The steam barge *Edwin S. Tice*, of Milwaukee, Wis., ran into the North Pier at a point 180 feet from its outer end on the 29th of July, 1896, breaking all the side timbers above the water level. This has not yet been repaired, but the owners, lately reminded of the neglect, have notified this office that preparations are on foot for the speedy execution of this work.

On the 28th of June I made an examination of the harbor entrance and up the river from the lake to Rush Street Bridge. The river channel was found to be uniformly in good condition, with nowhere less than 18 feet in depth in the main channel, but generally from 19 to 20 feet, and even more. In the lake, however, at the immediate approach and to the south of the entrance, a bar has formed, as indicated on the sketch submitted herewith. Over a portion of this bar there is only from 15 to 17 feet depth of water, and heavily laden vessels about to enter the harbor from the southward are liable to ground on it. The removal of about 10,000 cubic yards of dredged material would much improve the condition here. The outer basin was also examined on the same day, and the soundings on the sketch just referred to show the result of this examination.

Based on these soundings an estimate of cost of deepening the basin was made, as follows:

For dredging the area limited by the easterly breakwater in the east, the Lake Front Park bulkhead in the west, the South Pier and Illinois Central Railroad Company's wharf in the north, and the southerly breakwater in the south, and to within 50 feet of the several piers mentioned, to a uniform depth of 18 feet below Chicago City datum or 20 feet below mean lake level. This will require—

2,058,300 cubic yards, at 20 cents per cubic yard	$411,660
Add 10 per cent for contingencies, etc	41,166
Total cost	452,826

The figures in the above estimate is based on scow measurements.

No work is contemplated for the year ending June 30, 1899, save the reading of the water gauge and the proper care of United States property.

A table, intended as an aid in the rapid preparation of estimates of cost of crib work and of the amount of materials required therein, according to the types shown in the report for 1896, was submitted last year, but was not printed in the report. As, however, the explanation of the table was allowed to remain in the report, it is believed that the omission of the table was accidental, and it is therefore again submitted with this report.

I am, Major, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

Formulæ for securing estimates for crib work (100 feet in length).

IMPORTANT NOTE: X = C − 10; C = the number of courses above the *lake bottom*; each course = 1 foot, except the bottom course of the crib work, which is 1½ feet. Thus, for a 20-courses high crib on 2-foot pile foundation, C = 22 and X = C − 10 = 12.

Style of crib.	Approximate cost, expressed in dollars.	Amount of timber, expressed in "M" feet B. M.	Iron, expressed in hundredweights.		Amount of stone, expressed in cords of 128 cubic feet.	Piles.
			Drift bolts.	Screw bolts.		
16 feet wide on pile foundation	$Y = 201.3\,X + 2{,}522.4$	$Y' = 4.64\,X + 54.36$	$Y'' = 4.4\,X + 36.4$	4.8	$Y''' = 9.7\,X + 90.7$	27
20 feet wide on pile foundation	$Y = 229.2\,X + 3{,}022.3$	$Y' = 5\,X + 64.28$	$Y'' = 4.6\,X + 39.0$	7.8	$Y''' = 12.8\,X + 99.2$	40
24 feet wide on pile foundation	$Y = 254.5\,X + 3{,}372.3$	$Y' = 5.3\,X + 73.17$	$Y'' = 4.8\,X + 41.0$	7.8	$Y''' = 15.7\,X + 117.3$	40
30 feet wide on pile foundation	$Y = 294.1\,X + 3{,}799.5$	$Y' = 5.7\,X + 79.34$	$Y'' = 4.9\,X + 42.0$	9.6	$Y''' = 20.1\,X + 129.2$	53
30 feet wide on stone foundation	$Y = 294.1\,X + 2{,}797.6$	$Y' = 5.7\,X + 32.52$	$Y'' = 4.9\,X + 16.2$	0	$Y''' = 20.1\,X + 306.4$	0

Composite formula to be used to compute the cost of crib work at selected prices.

16 feet wide on pile foundation	$Y = (4.7\,T + 4.4\,D + 9.7\,S)\,X + 27\,P + 5\,Q + 54.4\,T + 36.4\,D + 90.7\,S.$
20 feet wide on pile foundation	$Y = (5\,T + 4.6\,D + 12.8\,S)\,X + 40\,P + 7.7\,Q + 64.3\,T + 39.0\,D + 99.2\,S.$
24 feet wide on pile foundation	$Y = (5.3\,T + 4.7\,D + 15.7\,S)\,X + 40\,P + 7.7\,Q + 73.2\,T + 41.0\,D + 117.3\,S.$
30 feet wide on pile foundation	$Y = (5.7\,T + 4.9\,D + 20.1\,S)\,X + 53\,P + 9.6\,Q + 79.4\,T + 41.7\,D + 129.2\,S.$
30 feet wide on stone foundation	$Y = (5.7\,T + 4.9\,D + 20.1\,S)\,X + 32.6\,T + 16.2\,D + 306.4\,S.$

In these formulæ the "selected prices" are represented as follows: T = price per 1,000 feet B. M. of timber; D and Q = prices per hundredweight of drift and screw bolts, respectively; S = price per cord of stone, and P = price per pile (all "in place").

For superstructure omit the second term in the second member (in formulæ of the "upper" table) and make X = the required number of courses.

For decking $Z\$ = w\,(0.592\,T + 0.456\,D)$; w = width to be covered.

For further explanations see Chief Engineer's Report, 1896, p. 2578 and tables.

Means of tridaily readings of the gauge at Chicago Harbor, Illinois, 1897

[Plane of reference: Low water of 1847.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	—0.80	—0.50	—0.80	0.03	0.40	0.40	0.77	0.70	0.30	0.27	0.83	—0.30
2	—1.00	—0.50	—0.50	—0.33	0.60	0.60	0.60	0.93	0.43	0.40	0.57	—0.27
3	—0.53	—0.63	—0.67	—0.10	0.37	0.53	0.50	0.83	0.40	0.17	—0.03	—0.10
4	—1.03	—0.63	—0.93	—0.30	0.07	0.27	0.43	1.00	0.30	0.07	—0.20	—0.10
5	—0.84	—0.70	—0.80	—0.47	0.03	0.47	0.40	0.93	0.33	—0.10	—0.43	—0.10
6	—0.83	—0.57	—0.23	—0.20	0.27	0.37	0.60	0.80	0.40	0.00	—0.18	—1.00
7	—0.70	—0.77	—0.50	—0.37	0.33	0.37	0.60	0.87	0.50	0.47	—0.43	—0.53
8	—0.67	—0.63	—0.90	—0.10	0.20	0.40	0.67	0.80	0.43	—0.23	0.27	—0.37
9	—1.13	—0.67	—0.63	—0.23	0.10	0.60	0.37	0.90	0.33	0.30	0.40	—0.43
10	—1.17	—0.83	—0.93	—0.33	—0.03	0.43	0.63	0.93	0.30	0.13	—0.53	—0.43
11	—0.83	—0.57	—0.70	—0.20	0.23	0.63	0.77	0.80	0.73	—0.03	0.17	—0.13
12	—0.43	—0.47	—0.37	—0.20	0.10	0.30	0.87	0.80	0.47	—0.20	—0.37	—0.20
13	—0.70	—0.80	—0.20	—0.37	0.23	0.43	1.00	0.67	0.40	—0.03	—0.40	0.20
14	—0.67	—0.60	—0.37	—0.17	0.23	0.33	0.70	0.47	0.43	—0.13	—0.23	0.10
15	—0.90	—0.97	—0.70	—0.27	0.17	0.40	0.60	0.57	0.47	—0.13	0.27	—0.13
16	—0.73	—0.90	—0.60	0.23	0.10	0.47	0.77	0.73	0.63	0.47	—0.20	—0.57
17	—0.60	—0.93	—0.60	—0.07	0.13	0.40	0.77	0.47	0.47	0.33	—0.33	—0.47
18	—0.90	—1.07	—0.73	—0.87	0.07	0.60	0.70	0.60	0.13	0.13	—0.13	—0.66
19	—0.63	—0.83	—0.33	—0.40	0.23	0.67	0.70	0.83	0.73	0.23	—0.13	—0.20
20	—0.80	—0.97	—0.57	—0.60	0.30	0.67	0.70	0.57	0.70	0.23	—0.30	—0.33
21	—0.63	—0.63	—0.77	—0.47	0.47	0.47	0.67	0.43	0.00	0.23	0.37	—0.47
22	—0.93	—0.37	—0.43	—0.56	0.17	0.43	0.57	0.67	0.37	0.27	0.20	—0.37
23	—0.57	—0.83	—0.17	—0.63	0.20	0.40	0.60	0.73	0.50	—0.03	—0.33	—0.37
24	—0.70	—1.27	—0.10	—0.37	0.37	0.73	0.63	0.60	0.37	0.20	—0.50	—0.53
25	—0.87	—0.63	—0.47	—0.47	0.43	0.47	0.60	0.57	0.27	0.27	0.40	—0.70
26	—1.23	—0.63	—0.40	—0.20	0.53	0.37	0.83	0.57	0.67	0.13	0.80	—0.70
27	—0.93	—1.07	—0.33	—0.30	0.43	0.47	0.87	0.60	0.40	0.17	—0.23	—0.60
28	—0.67	—0.67	—0.40	0.00	0.37	0.73	0.70	0.43	0.20	0.17	—0.10	—0.33
29	—0.73	.....	—0.33	0.70	0.30	0.63	0.87	0.40	0.07	—0.07	—0.10	—0.77
30	—0.77	.....	—0.23	0.70	0.33	0.47	0.70	0.23	0.07	0.17	—0.77	—0.53
31	—0.77	.....	—0.17	.....	0.13	.....	0.67	0.43	.....	0.33	.....	—0.10
Means	—0.80	—0.70	—0.51	—0.23	0.25	0.48	0.67	0.67	0.39	0.14	—0.08	—0.37

J J 2.

IMPROVEMENT OF CHICAGO RIVER, ILLINOIS.

This river constitutes the inner harbor of Chicago, Ill. Its navigable parts lie wholly within the city limits of Chicago.

In the Annual Report of the Chief of Engineers for 1893, page 2974, may be found a full report upon this stream and its needed improvement, and in his Annual Report for 1897, page 2793, a history of the improvement and some detailed information as to the obstructions to navigation existing along its channels.

The present project was adopted by Congress in the river and harbor act of June 3, 1896, and modified by the sundry civil act of June 4, 1897. It contemplates dredging the river and its branches from the mouth of the river to the Stock Yards on the South Branch and to Belmont avenue on the North Branch, as far as may be admitted by existing docks and wharves to allow passage by vessels drawing 16 feet of water; also to acquire title to and cut away certain obstructive bends and projecting docks that narrow and obstruct the channel.

CONDITION OF THE WORK JUNE 30, 1898.

At the close of the fiscal year ending June 30, 1897, the work of dredging was in progress on the South Branch, under contract, dated November 5, 1896, with Green's Dredging Company, and 258,966 cubic yards had been removed under this contract; and on the North Branch, under contract of same date with the Lydon & Drews Company, 248,610 cubic yards had been dredged under this contract.

During the past fiscal year these contracts have been in force, and under them there have been removed:

	Cubic yards.
From the South Branch	344,426.3
From the North Branch	509,925.7
Making a total dredged during the year	854,352.0

The dredging to 17 feet was carried from the mouth of the river to the Stock Yards, on the South Branch, and under the terms of the contract redredged or "cleaned up" and accepted from the Stock Yards to Adams Street Bridge. This contract will be completed in July, 1898.

On the North Branch dredging has been carried from the forks of the river to Fullerton avenue, but no part of this channel has been redredged. It is probable that this work will not be completed the present season, as far as the final cleaning up is concerned, but it is expected to complete the primary dredging throughout the full extent of the project.

It must be remembered that the preliminary estimates of quantities to be dredged under these contracts were based on surveys made in 1889–90 by this office, and in 1892 by the Chicago drainage authorities. The river is an open sewer, into which is cast the waste from a population of about one and a quarter million people, or two-thirds the population of the city, and all the solids washed from streets, tanneries, slaughter-houses, and filth-producing manufacturing establishments along its banks.

The daily deposits will probably average in excess of 1,000 cubic yards, even after the matter in suspension is to a large extent carried off by the Illinois and Michigan Canal. To this extent, then, we may expect our dredging to be constantly increased while the contracts are in operation, and to this extent will the quantities named in the contracts as the approximate amounts be found deficient.

The original project contemplated only the obtaining of the depth stated throughout the limits specified, and that thereafter the city of Chicago would maintain these dimensions by removing the filth it casts into the stream for its own convenience. There will be required constant dredging by one dredge in each branch to maintain the channels, or, say, an appropriation of $35,000 to $50,000 per annum to maintain the channels. If this annual dredging is not done, the results of the work now nearing completion will have disappeared in four years. It is evident that the use of the river as an outfall and receptacle for city sewage and filth should be prohibited or means be found to compel the removal of this material so cast into navigable streams at the expense of the community responsible for it.

WIDENING OF THE RIVER.

Prior to the passage of the sundry civil act of July 1, 1898, no money was available to pay expenses of acquiring title to lands needed for widening the river at certain points under the adopted project, but much preliminary work has been done, viz: Maps, plats, and descriptions of all lots of land required have been made, areas computed, and forms of proposals for purchase and sale made out and printed. The general project, showing approximately the lots required and the estimated cost of the same, has been approved by the Secretary of War.

PROPOSED APPLICATION OF FUNDS ON HAND AND THOSE ASKED FOR FISCAL YEAR ENDING JUNE 30, 1900.

It is proposed to continue the work under contracts now in force to completion; to secure title as rapidly as practicable to the pieces of land required for rectifying the channel under the approved project, and to put this work under contract as far as permissible under the laws of the United States. The acquisition of title will be a long process.

Much of the delay will result from the fact that the improvement is evidently not worth the property taken from the men seeking the improvement, who, as far as ascertained, will demand full damages as well as values for plats taken. On the Calumet River a free right of way was a prerequisite to the expenditure of money; on the Chicago River this right must be condemned and paid for, although as far as immediate benefits are concerned they are exclusively for the advantage of the riparian owners of property, as there are no public landings or docks along this river.

If of the importance alleged and insisted upon, the improvement could rapidly be secured by providing a right of way, as was done along the Calumet River prior to 1889.

Appropriations.

Act June 3, 1896	$50,000.00
Sundry civil act June 4, 1897	113,000.00
Sundry civil act July 1, 1898	400,000.00
Total	563,000.00
Expenditures to June 30, 1898 (exclusive of $25,000 allotted from appropriation for Chicago Harbor of August 17, 1894)	112,126.70
Balance unexpended July 1, 1898	450,873.30

Money statement.

July 1, 1897, balance unexpended	$138,524.79
Amount appropriated by sundry civil act approved July 1, 1898	400,000.00
	538,524.79
June 30, 1898, amount expended during fiscal year	87,651.49
July 1, 1898, balance unexpended	450,873.30
July 1, 1898, amount covered by uncompleted contracts	41,355.68
July 1, 1898, balance available	409,517.62
Amount (estimated) required for completion of existing project	137,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	137,000.00
Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

List of contracts for improving Chicago River, Illinois, in force during fiscal year ending June 30, 1898.

Name and address of contractor.	Nature of contract.	Date.	To expire.
Green's Dredging Co., Chicago, Ill.	Dredging main river and South Branch.	Nov. 5, 1896	Nov. 30, 1898
Lydon & Drews Co., Chicago, Ill	Dredging North Branch	do	Do.

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 2, 1898.

MAJOR: I have the honor to submit herewith a report on operations in Chicago River, Illinois, during the year ending June 30, 1898.

Two contracts have been in force during the year, viz, with the Green's Dredging Company, for work in the Main and South branches to the Stock Yards, and with the Lydon & Drews Company, for work in the North Branch to Belmont avenue. Both the contracts were dated November 5, 1896, and both the contractors are of Chicago, Ill. The work under each of the contracts consists in deepening the channel to 17 feet below low water and to within 15 feet of existing docks.

WORK DONE DURING THE YEAR.

A. *In the Main and South branches.*—At the close of the fiscal year 1897 the channel was improved to Ashland avenue in the West Fork of the South Branch and to Thirty-third street in the South Fork, and 258,966.7 cubic yards of material were removed. Between the 1st of July and the 17th of December, 1897, when operations were suspended for the season, 280,392.1 cubic yards were dredged, by which the work was completed to the Stock Yards (in September) and the channel was redredged from that place back to Canal street.

The redredging was provided for in the specifications and was found very much needed, for, although the first work was generally done to one foot, and frequently more, below the required plane, the subsequent shoaling proved quite considerable. As a provision is made in the specifications for a deduction from the estimates of all material removed from below the fixed grade, the contractors did not deem it safe to go any deeper than as stated above. The shoaling is caused partly by the inflow from numerous sewers and partly by the undredged parts (near the docks and inside of protection piers, etc.), from which, when stirred up by passing propellers, deposits run into the channel.

The work of the present season was resumed on the 30th of April, and at the close of the year 344,426.3 cubic yards had been removed in all since the beginning of the year. The reason for resuming this season's work at so late a date was the crowded condition of the river, the vessels being very slow this year in leaving their winter quarters.

On the 30th of June the channel was redredged to Washington Street Bridge. The work to Adams Street Bridge has been inspected and formally accepted. The shoaling and consequent redredging has considerably increased the amount to be dredged. The original estimate gave the amount required at 458,427 cubic yards. This estimate was made from the comparatively few soundings shown on the maps of the Chicago Sanitary District's survey of some three years previous, and close results could, therefore, not be expected, the more so as considerable shoaling had undoubtedly occurred in the intervening time. One hundred thousand cubic yards were added to the original amount, but even this increased figure has already been exceeded. The progress of this season's work has not been as favorable as that of last season. The shallow cuts in redredging, the frequent interference by vessels passing or unloading at the docks, and the always inconvenient work in the draws of the many bridges have all combined to retard the progress of the work.

B. *In the North Branch.*—At the close of the fiscal year ending June 30, 1897, the main channel of the North Branch was dredged to North avenue. About three-fourths of the length of the North Branch Canal was also completed, and there were removed during that year a total of 248,610.3 cubic yards of material.

Operations were continued during the succeeding year until the 20th of December, when the plant was laid up for the winter. Work was resumed on the 22d of March at Webster Avenue Bridge, which place had been reached at the close of the work in December. At the end of the year, June 30, 1898, the channel was practically completed up to Fullerton avenue, and 509,925.7 cubic yards in all were removed during the year, making an average of 56,658 cubic yards per month of actual work. The "North Branch Canal" was completed during the month of August. Dredging this "canal" was not originally estimated for; nor was the deepening of the channel through the east draws of the three bridges at Kinzie street, which latter channel has heretofore never been dredged, but which was now done to enable tugs to pass up or down while, as often happens, the west draw is occupied by one or more vessels. This additional work will increase the amount of the original estimates. No piles or old docks were removed during the year. Very hard material was found in the vicinity of Fullerton avenue, which has retarded the progress considerably.

C. *Widening of the river.*—In pursuance of an authority contained in the sundry civil act of June 4, 1897, providing for the widening of the river at the most

obstructive places, and in anticipation of an appropriation for that purpose, the preliminary steps were taken during the year by way of preparing plats showing tracts of land proposed to be condemned and removed, and also the legal descriptions of such tracts, the computed areas thereof, etc.

TOTAL WORK DONE UNDER THE CONTRACTS.

Since the beginning of work under the contracts in November, 1896, the channel has been deepened in the Main and South branches, between Rush street and the Stock Yards, and has been redredged from the last-named place back to Washington street, by the removal of in all 603,393 cubic yards of dredged material and 11 piles. Final soundings have been taken and the work accepted from the south limits to Adams street.

In the North Branch the channel has been dredged to Fullerton avenue, including the "North Branch Canal," and 758,536 cubic yards of dredged material and 2 piles have been removed. No part of the channel in this branch has as yet been finally accepted.

WORK PROPOSED FOR THE ENSUING YEAR.

It is proposed to continue and complete the work under both of the now existing contracts during the ensuing year, and if funds become available it is also proposed to proceed with the widening of the river in accordance with the project submitted and approved by the Secretary of War.

A table showing the means of tridaily readings of the water gauge at the mouth of the river during the year 1897 is respectfully submitted herewith.

I am, Major, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

J J 3.

IMPROVEMENT OF CALUMET HARBOR, ILLINOIS.

The object of the work is to provide a deep entrance to the Calumet River and the port of South Chicago, which object is effected in the usual manner by first protecting the proposed channel against drift by parallel piers or jetties—in this case 300 feet apart, projecting into the lake from the shore at the river's mouth—and by dredging between them to the proper depth.

CONDITION OF THE WORK JUNE 30, 1896.

Work was begun on this harbor in 1870, and prior to June 30, 1896, 2,020 linear feet of the south pier and 3,640 linear feet of the north pier had been completed, and a channel 16 feet in depth between the piers had been secured and maintained, which completed the old project for this improvement.

CONDITION OF THE WORK JUNE 30, 1898.

The river and harbor act of June 3, 1896, adopted for this harbor a project submitted June 30, 1895, which provided for a channel depth of 20 feet, a prolongation of the south pier 1,200 linear feet and the north pier 500 linear feet.

Prior to the adoption of this project by Congress, by authority of the Chief of Engineers a narrow channel 20 feet in depth, barely practicable, had been begun under contract, leading from deep water in Lake Michigan as far as to the Illinois Steel Company's slip.

In February, 1896, a project supplementary to that of June 30, 1895, was submitted and published as House Executive Document No. 277 (see also Report of Chief of Engineers, U. S. A, 1896, p. 2584), which covered not only the requirements of the entrance to Calumet River, or the present harbor, but all the present needs of this locality. This extended project contemplated an outer breakwater, in continuation of the north pier of the Illinois Steel Company's harbor, to shelter the entrance to Calumet River and the steel company's harbor, and to form a sheltered roadstead to be dredged to 20 feet deep; the extension of the south pier 800 linear feet, and dredging the entrance to the river, and the river itself for a distance of 2 miles, for a width of 200 feet and to a depth of 20 feet.

Congress in making appropriations for Calumet Harbor adopted the project of June 30, 1895, but in appropriating for the river adopted that part of the later project of February, 1896, relating to the 20-foot channel in Calumet River.

The outer breakwater is an urgent necessity, and if it be built the north pier of Calumet Harbor should not be extended, and the extension of 800 feet is sufficient for the south pier.

From the movement of sands in this vicinity it is very apparent that one of these projects should be more definitely adopted. The drift into the channel can only be stopped by the intervention of a solid obstruction or pier, and it is apparent that any material extension of the piers of the United States harbor will result in closing the approaches to the Illinois Steel Company's harbor by the sand caught and held against the United States piers.

Such a result should be avoided, and the harbors can both be protected by extending the north pier of the Illinois Steel Company's pier, as proposed in the report of February 26, 1896, while at the same time such a construction would make access to the docks at South Chicago possible at all conditions of weather. At present the entrance to the harbor can not be safely made by vessels during high winds or gales, and continuous dredging will soon be required to keep the channels navigable.

By authority of the Chief of Engineers the appropriation made by the act of June 3, 1896, has been applied to the execution of the work common to both projects named above, i. e., to the extension of the south pier 800 linear feet and to dredging the channel between the piers and to a similar depth below the low water of 1847. All this work had been done by contract before the end of the fiscal year ending June 30, 1897.

At the beginning of the fiscal year just ended, a contract, dated June 14, 1897, with George Cooper, of Manitowoc, Wis., for rebuilding superstructure over 500 linear feet of the north pier near its outer extremity was under way. This contract was completed September 7, 1897. The amounts of work done under this contract are given in detail in the report of Assistant Engineer G. A. M. Liljencrantz, hereto appended.

At present there is a good channel 20 feet deep at present stage of water between the piers, but storms have somewhat filled the channel seaward of the piers with drifting sand. Vessels, however, of the largest size and draft that can use the so-called 20-foot channel between the upper Great Lakes can freely enter and leave the harbor.

In the last annual report it was given as a noteworthy fact that the *Queen City* had taken a cargo of 5,800 short tons of corn from South Chicago to Buffalo, but such cargoes already seem small at this port.

During the present season the steamer *Superior City*, on a mean draft of 18 feet 2 inches, carried 266,550 bushels of corn, or 7,463 short tons, from South Chicago (Calumet Harbor) to Buffalo.

This steamer unloaded at this port 6,754 gross tons of iron ore in twelve hours, and took on board her great cargo of 7,463 short tons in seven hours.

These facts are given as indicating the rapidity of modern methods of transferring cargoes at this and other lake ports.

This harbor is now the finest on Lake Michigan, capable of receiving and accommodating the largest vessels yet afloat or projected on the Great Lakes, as long as the bar at its mouth may be kept dredged. The construction of an exterior breakwater, now so urgently needed, will leave but little to be desired at the present stage of development of wharfage at South Chicago.

The freights have mainly consisted in heavy, bulky articles, such as coal, iron ore, salt, grain, and timber, which require the largest vessels, the cheapest freight rates, and most commodious channels. The iron ore comes in great part from natural harbors of superior depth, and cargoes have been limited by the depth of water at South Chicago. Consequently the increased channels have been at once availed of and have been followed by cargoes that would have been inconceivable two years ago. For the reasons stated above, the average vessel trading at this port very much exceeds that at any other port in the world.

PROPOSED APPLICATION OF FUNDS NOW AVAILABLE.

The small amount of money now on hand will be held as an emergency fund, to keep the channel open across the bar near the mouth of the harbor and to make such repairs as may become necessary by accident or otherwise.

PROPOSED APPLICATION OF FUNDS ASKED FOR FOR FISCAL YEAR ENDING JUNE 30, 1900.

The fact that there are two projects for this locality, parts of each of which have been adopted by Congress, make it necessary to state the facts again explicitly. There remains to be done under the project of June 30, 1895, 400 linear feet in extension of the south pier and 500 linear feet in extension of the north pier and some minor work, at an estimated cost of $79,550.

Under the supplementary project of February 21, 1896, there remains to be done the construction of the outer harbor, and if this latter project be adopted, the 900 linear feet of pier extension in the former project is entirely unnecessary. The outer harbor sooner or later must be built as a necessity, and it would result in a saving of $79,550 if future appropriations went toward the construction of the works demanded by the later project and no further work be done under the project of June 30, 1895.

The estimate submitted is therefore to be considered as for the construction of the outer harbor under the project or report of February 21, 1896.

It is proposed to apply such funds as may be granted under this project to extending the outer breakwater on the same line as the shore end of the north pier of the Illinois Steel Company's harbor and to redredging the bar at the mouth of Calumet Harbor.

Appropriations.

By act of—		By act of—	
July 11, 1870	$50,000.00	August 5, 1886	$10,000.00
March 3, 1871	50,000.00	August 11, 1888	20,400.00
June 10, 1872	40,000.00	September 19, 1890	20,000.00
March 3, 1873	40,000.00	July 13, 1892	15,000.00
June 23, 1874	25,000.00	August 18, 1894	15,000.00
March 3, 1875	25,000.00	June 3, 1896	75,000.00
August 3, 1876	20,000.00		
June 18, 1878	15,000.00	Total	537,400.00
March 3, 1879	12,000.00	Expended to June 30, 1898	523,853.71
June 14, 1880	20,000.00		
March 3, 1881	30,000.00	Balance unexpended June 30, 1898	13,546.29
August 2, 1882	35,000.00		
July 5, 1884	20,000.00		

Money statement.

July 1, 1897, balance unexpended	$24,668.72
June 30, 1898, amount expended during fiscal year	11,122.43
July 1, 1898, balance unexpended	13,546.29
Amount (estimated) required for completion of existing project of February 21, 1896	1,009,830.00
Amount (estimated) required for completion of existing project of June 30, 1895	79,550.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	300,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

List of contracts for improving Calumet Harbor, Illinois, in force during fiscal year ending June 30, 1898.

Name and address of contractor.	Nature of contract.	Date.	To expire.	Remarks.
George Cooper, Manitowoc, Wis.	Rebuilding superstructure.	June 14, 1897	Aug. 31, 1897	Extended to Sept. 30, 1897, and completed Sept. 9, 1897.

COMMERCIAL STATISTICS.

Amount of revenue collected at nearest port of entry (Chicago) during the fiscal year 1898, $4,179,879.94.

Arrivals and clearances of vessels at Calumet Harbor.

	Arrived.		Cleared.	
	Number.	Tons.	Number.	Tons.
Steam	966	1,451,302	955	1,382,941
Sail	526	678,585	522	649,518
Total	1,492	2,129,887	1,477	2,032,459

Receipts and shipments by lake at South Chicago, Ill., during calendar year 1897.

Receipts.	Tons.	Shipments.	Tons.
Coal	257,064	Steel rails	63,246
Iron and iron ore	1,734,086	Coal	7,815
Salt	151,253	Iron and rails	5,300
Grain and seed	15,406	Oil	41,034
Cement and plaster	4,612	Grain	995,820
Lumber, wood, etc	195,407	Glass	3,127
Miscellaneous merchandise	5,109	Miscellaneous merchandise	14,839
Total	2,362,937	Total	1,130,281

Comparison of receipts and shipments at South Chicago for five calendar years—1893, 1894, 1895, 1896, and 1897.

Years.	Tons.	Years.	Tons.
1893	903,379	1896	2,973,724
1894	1,436,897	1897	3,493,218
1895	2,857,750		

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 1, 1898.

MAJOR: I have the honor to submit herewith a report on operations in Calumet Harbor, Illinois, during the fiscal year ending June 30, 1898.

On the first day of the year there were two contracts in force for work of improving this harbor, viz: With the Hausler & Lutz Towing and Dock Company, of South Chicago, Ill., for the extension of the South Pier 800 linear feet, and with George Cooper, of Manitowoc, Wis., for the rebuilding of the superstructure over 500 linear feet of the North Pier.

Work under the first of these two contracts was completed on the last day of the previous year, or June 30, 1897, but the final payment, including all retained percentages, was made on the 1st day of July following, and the contract was thus formally closed on that day.

The work of rebuilding the superstructure over the North Pier, begun during the previous year, was completed on the 7th of September, 1897.

WORK DONE DURING THE YEAR.

The actual work of rebuilding the superstructure over the North Pier, under contract dated June 14, 1897, with George Cooper, of Manitowoc, Wis., was begun on the 6th of July, the preliminary work only—the removal of the old superstructure—having commenced during the previous year.

The contract was to have expired on the 15th of August, but an extension of time was granted to September 30, 1897.

Under the terms of the contract the outer, or easterly, 483 linear feet of the superstructure over the North Pier were rebuilt, and a clump of piles was placed at the end thereof, in which work the following materials were used and paid for, viz: 133,390 feet B. M. pine timber, 13 oak piles, 17,524 pounds of wrought-iron drift bolts, 210 pounds of Ulster iron dredge chain, and 67,913 cords of stone.

The total cost of this work was $4,081.75, making an average cost per linear foot of $8.45.

In addition to the work just described, the corners at the end of the pier were strengthened—under a special agreement with the contractor—by surrounding them with sheets of boiler iron, which were secured with screw bolts, passing through the side and end timbers alternately, into an upright placed in the respective inside corners. In this part of the work the following materials were used: 560 pounds of boiler iron and 240 pounds of wrought-iron screw bolts, with nuts and washers.

The clump of piles was made of 13 piles, instead of 7, as used heretofore, but which has on several occasions proved insufficient. The usefulness of this clump was demonstrated one day in September last, when one of the car ferries, heavily laden, ran into it and would undoubtedly have done serious damage to the pier had the protection not been there. The work under this contract was completed on the 7th of September, 1897.

PRESENT CONDITION OF THE HARBOR.

The Illinois Steel Company has done more or less dredging in the lake and between the United States piers, and the channel is at present in good condition. The north pier is in very good condition east of the steel company's slip, but the revetment westward therefrom is entirely broken up. The south pier is also in good condition, with the exception of about 550 linear feet, which will require new superstructure before long. Three hundred and fifty feet of this old part are very much decayed and broken up.

GENERAL REMARKS.

The old frame beacon light, at the end of the north pier, was replaced during the year by a new iron light-house tower. This work was done by the United States Light-House Department and was completed on the 16th of October, 1897. The new tower is a cylindrical iron structure, containing a base, two stories, and a lantern chamber, and rests on a concrete foundation, which is 7.5 feet high and reaches down about to the low-water level of 1847, a space having been left open for that purpose in the new superstructure. The apparatus is a fourth order, fixed, red light, illuminating an arc of 180 degrees. The focal plane is 30 feet above the top of the pier, or (about) 37½ feet above the low-water level. The center of the tower is 33 feet from the end of the pier. The light in the new tower was installed on the 7th of October. The water along the north face of the pier, near the tower, has an average depth of 20 feet, and the bottom of the crib, which rests on a pile foundation, is only 16½ feet below low water, wherefore it is thought quite desirable to have some riprapping placed here, to insure safety to the tower.

The chief features representing the activity at the Illinois Steel Company's South Works, located north of the harbor entrance, are as follows:

The number of vessels arriving at the works during the year was 790, of which 690 were ore laden, the balance carrying other freight. The following materials were received, viz, 1,950,581 gross tons of ore, 15,000 gross tons pig iron, and 1,886,516 feet B. M. lumber. The ore-carrying vessels carried an average cargo of 2,827 gross tons. The largest cargo received, on June 10, 1898, was brought by the steamer *Superior City*, the principal dimensions of which are: 446 feet in length, 50 feet beam, and 18.2 feet draft. This cargo, amounting to 6,688 gross tons, was unloaded by 117 men in 11½ hours, or at the rate of 569 tons per hour. Shipments by lake destined to England, Japan, Corea, Canada, etc., amounted to 70,830 gross tons.

The office building, located on the United States light-house reservation, was repaired under authority received from the Department in November, 1897. This work was completed in February, 1898, at a cost of $64.99.

Some damage was done last fall to the south pier, at a point 2,000 feet west of the outer or easterly end of it, by the car ferry No. 2 running into it. The north pier sustained damage also from collision with some unknown vessel on the night between the 25th and 26th of April last, at a point distant 1,170 feet east of the steel company's slip. The top timber was here broken into splinters for a distance of 10 feet. No one has been found who witnessed the accident.

A map showing the work done during the year is respectfully submitted herewith.

WORK PROPOSED FOR THE ENSUING YEAR.

Should an appropriation be made it is proposed to commence the construction of the northerly breakwater, for the protection of the harbor entrance and the anchorage area in front thereof, during the ensuing year.

I am, Major, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

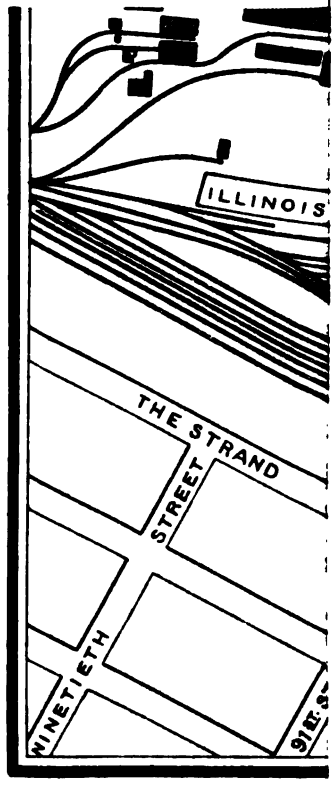
To Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

JJ 4.

IMPROVEMENT OF CALUMET RIVER, ILLINOIS AND INDIANA.

The object of this work as originally projected was to secure a channel 16 feet in depth, 200 feet wide, from the mouth of the river to one-half mile east of Hammond, Ind., to increase the facilities for handling the commerce of this region and to give relief to the overcrowded port of Chicago.

The history of the work, especially as regards the conditions imposed by various river and harbor acts of Congress, may be found in the Annual Reports of the Chief of Engineers prior to 1890, especial attention being invited to the Report of 1889, page 2142.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The United States have acquired the right of way and releases from claims for damages by reason of the improvement of Calumet River over the stretch from the mouth of the river to the outlet from Lake Calumet, the limits of the improved channel to be dock lines 200 feet apart, which have been established by authority of the Secretary of War.

The improvement above the forks, or from the forks to one-half mile east of Hammond, Ind., can not be made of the full width of 200 feet until the right of way and releases from damages have been acquired by the United States. In view of this fact, under provisions of various acts of Congress, the work has been subdivided into two sections—

(1) From the mouth of the river to the forks of the Calumet (below the forks).

(2) From the forks to one-half mile east of Hammond, Ind.

No steps have been authorized by Congress or undertaken by parties interested to secure rights of way and releases from damage claims for the improvement above the forks, and consequently work has been carried on in desultory fashion over that section in an attempt to secure a channel 60 feet wide and 10 feet deep. This section is part of an old river, now dead, or without current to carry off the filth cast into it from slaughterhouses and manufactories near Hammond and from sewers of the town. The dredged channels were filled up with filthy deposits as fast as excavated, and after repeated attempts to secure the depths sought the work was abandoned in 1895 for reasons more fully given in the Report of the Chief of Engineers, United States Army, for that year.

On the lower section of the river, or from its mouth to the forks of the Calumet—this section lies wholly within the State of Illinois—systematic work has been carried on since 1888 up to the close of the fiscal year 1896 to secure a channel 200 feet wide and 16 feet deep, and prior to that date the work had been extended as far as to One hundred and eighteenth street crossing, a distance of 3¾ miles, with the exception of a short stretch of rock and hard pan, involving the future excavation of about 9,000 cubic yards of rock in place, over which stretch the full depth channel is only 80 feet wide. The work deteriorated rapidly in depth near the upstream limit, and much of it had been dredged the second time.

In view of the rapid increase in size and draft of vessels on the Great Lakes, due to the near completion of an enlarged channel between Duluth, Chicago, and Buffalo, and of the impracticability of speedily providing elsewhere at Chicago a channel of sufficient capacity for such large vessels, Congress provided in the river and harbor act of June 3, 1896, that the Calumet River may be dredged to a depth of 20 feet for 2 miles southward from the mouth. The elevators, coal and salt docks, and principal establishments along the river are within this 2-mile limit.

CONDITION OF THE WORK JUNE 30, 1897.

There have been removed by dredging between the mouth of the river and One hundred and eighteenth street, in making the 16-foot channel, 1,436,358 cubic yards, and in maintaining this channel by redredging, 330,862 cubic yards, or, in all, on this 16-foot project, 1,767,220 cubic yards.

In dredging the 20-foot channel 2 miles have been completed to full dimensions, from which 320,405 cubic yards have been removed.

In the attempt to make and maintain a channel 60 feet wide and 10 feet deep from the forks to one-half mile east of Hammond, Ind., there has been done in primary dredging to make the channel 150,094 cubic yards, and in redredging 98,422 cubic yards. The channel is now in much worse condition than when the work began.

The channel below the forks fills in at the rate of about 22,340 cubic yards per mile per annum, and there remains about 300,000 cubic yards of redredging to restore the channel to its full depth between the end of the 20-foot channel, near One hundred and sixth street, and the end of the dredged 16-foot channel, at One hundred and eighteenth street. Above One hundred and eighteenth street boats carrying more than 7 feet can not pass, and in the vicinity of Hammond, Ind., it will be difficult for boats to navigate drawing as much as 5 feet.

WORK DONE DURING THE FISCAL YEAR ENDING JUNE 30, 1898.

At the close of the last fiscal year, ending June 30, 1897, work was in progress under contract dated September 1, 1896, with C. E. Mitchell & Co., Ludington, Mich., for deepening the 16-foot channel to 20 feet from the harbor to One hundred and sixth street, a distance of 2 miles. This contract was completed August 21, 1897, after removing 98,718 cubic yards of earth.

In all, there were removed from the channel under this contract 320,405 cubic yards of earth, all of which was towed out to deep water in the lake and dumped.

This channel, although somewhat deteriorated by fill subsequent to the dredging, is practically intact. In a few places there are depths less than 20 feet below the low water of 1847, but on account of the rise in the lake level there is a wide and good 20-foot channel throughout the reach.

Above One hundred and sixth street the dredged channel has very much deteriorated, there being only 11 to 12 feet to One hundred and tenth street, and thence to One hundred and eighteenth street the depth declines from 14 to 9 feet, and still less depths exist southward of One hundred and eighteenth street. The filling in from natural causes, aided by sewage and filth deposits, is very rapid in this stream, annually increasing in rate of deposit, and the maintenance of a practicable channel of sufficient dimensions is a matter that demands nearly constant dredging, under regular appropriations made therefor.

Further details of this work are given in the report (hereto attached) of Assistant Engineer G. A. M. Liljencrantz and on the map herewith.

There are practically no funds available for this work "below the forks," the amount reported available being the balance of an allotment made by Congress for the section of the river lying "between the forks and one-half mile east of Hammond, Ind.," on which section work has been suspended for reasons that have been heretofore reported.

This balance could well be applied to the lower river.

PROPOSED APPLICATION OF FUNDS ASKED FOR FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

It is proposed to apply these funds to maintaining the 20-foot channel, redredging the 16-foot channel from One hundred and sixth street to One hundred and eighteenth street, and to extending this channel southward under the original project.

Appropriations.

By act of—	
July 5, 1884	$50,000.00
August 5, 1886	30,000.00
August 11, 1886	50,000.00
September 19, 1890	50,000.00
July 13, 1892	75,000.00
August 18, 1894	45,000.00
June 3, 1896	50,000.00
Total	350,000.00
Expended to June 30, 1898	342,118.42
Balance unexpended June 30, 1898	7,881.58

Money statement.

July 1, 1897, balance unexpended	$32,663.72
June 30, 1898, amount expended during fiscal year	24,782.14
July 1, 1898, balance unexpended	7,881.58
Amount (estimated) required for completion of existing project	700,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Contract for improving Calumet River, Illinois, in force during fiscal year ending June 30, 1898.

Name and address of contractor.	Nature of contract.	Date.	To expire.	Remarks.
C. E. Mitchell & Co., Ludington, Mich.	Dredging	Sept. 1, 1896.	Sept. 1, 1897.	Completed Sept. 1, 1897.

REPORT OF MR. G. A. M. LILJENCRANTZ, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chicago, Ill., July 1, 1898.

MAJOR: I have the honor to submit herewith a report on operations in Calumet River, Illinois and Indiana, during the fiscal year ending June 30, 1898.

At the beginning of the year there was one contract in force, with Messrs. C. E. Mitchell & Co., of Ludington, Mich., dated September 1, 1896, for deepening the channel from the harbor to One hundred and sixth street, a distance of 2 miles, to a depth of 20 feet below low water, within the established dock lines, in accordance with a project approved by the river and harbor act of June 3, 1896. The contract provided for the removal of 320,000 cubic yards, more or less, of material, at the rate of 13½ cents per cubic yard. Work under this contract commenced on the 15th of September, 1896, and at the close of the fiscal year, June 30, 1897, 221,687 cubic yards of material had been removed, completing the channel for nearly 1½ miles and a turning basin, as described in last year's report.

WORK DONE DURING THE YEAR.

Work under the contract was continued during the year until the 31st of August, when it was completed to One hundred and sixth street, and accepted. Since the beginning of the year 98,718 cubic yards of material were removed and the 20-foot channel completed for the whole of the contemplated distance, 2 miles. No work

was done on the 16-foot channel south of One hundred and sixth street, owing to insufficiency of available funds.

On the 2d of September the contractors received the final payment, including all retained percentages, and the contract was closed.

Soundings taken after the completion of the work showed a depth of generally from 1 to 2 feet in excess of that specified and paid for, but nowhere less.

No work was done during the year "above the forks."

TOTAL WORK DONE UNDER THE CONTRACT.

Since the beginning of work under the contract the channel has been deepened to 20 feet below the Chicago city datum from the harbor to One hundred and sixth street, and a turning basin made in the old channel, opposite the Counselman elevators, by the removal of, in all, 320,405 cubic yards of material, all of which was conveyed in scows and dumped in the lake.

PRESENT CONDITION OF THE RIVER.

To ascertain the general condition of the river channel, an examination was made of this, on the 10th and 11th of June last, from the harbor to the forks. Lines were run zigzag and their location determined approximately. From among the soundings taken such were selected as represented the available channel, and these were plotted on a map submitted herewith. The result indicates that the 20-foot channel is practically intact, there being but a few places where a depth of less than 20 feet was found, among which may be mentioned the "turning basin" and a place opposite the now abandoned "Washington Ice Company's basin." In this latter the water had been kept at a level above that in the river, for the purpose of ice-making, and when this enterprise was abandoned the owners had a cut made from it to the river, letting out a great volume of water, and with it a considerable amount of silt and sand, which caused the shoaling at this place. Between One hundred and sixth and One hundred and tenth streets the available channel is only from 11 to 12 feet deep. From One hundred and tenth to One hundred and sixteenth street the depth diminishes gradually from 14 to 9 feet. North of One hundred and eighteenth street (the southerly limit of work done so far) considerable shoaling has taken place, leaving a channel of only 5 to 7 feet for a distance of some 1,000 feet. Dredging was originally made to 16 feet to this place. Between One hundred and eighteenth street and Chittenden Bridge the channel is from 9 to 10 feet in depth; thence to the "forks" it runs down to between 6 and 7 feet.

PROGRESS OF THE RIVER IMPROVEMENT.

A map showing the work done under the last contract and a table showing the progress of the improvement of this river, corrected up to date, are respectfully submitted herewith.

GENERAL REMARKS.

The last year has been an unusually quiet one, as regards new enterprises in the river region. The year's work at the Chicago Shipbuilding Company's docks is represented by the construction of the following vessels, viz:

The steamer *Wm. R. Linn*, 420 feet over all, 48 feet beam, and 28 feet deep, with a gross tonnage of 4,328.71, valued at $220,000.

The schooner *Australia*, 390 feet over all, 48 feet beam, and 26 feet deep, with a gross tonnage of 3,745.17, valued at $140,000.

There is at present on the stocks the barge *Maia*, the dimensions of which are 376 by 48 by 26 feet, and an order has been received for the construction of a fire-boat for the city of Chicago.

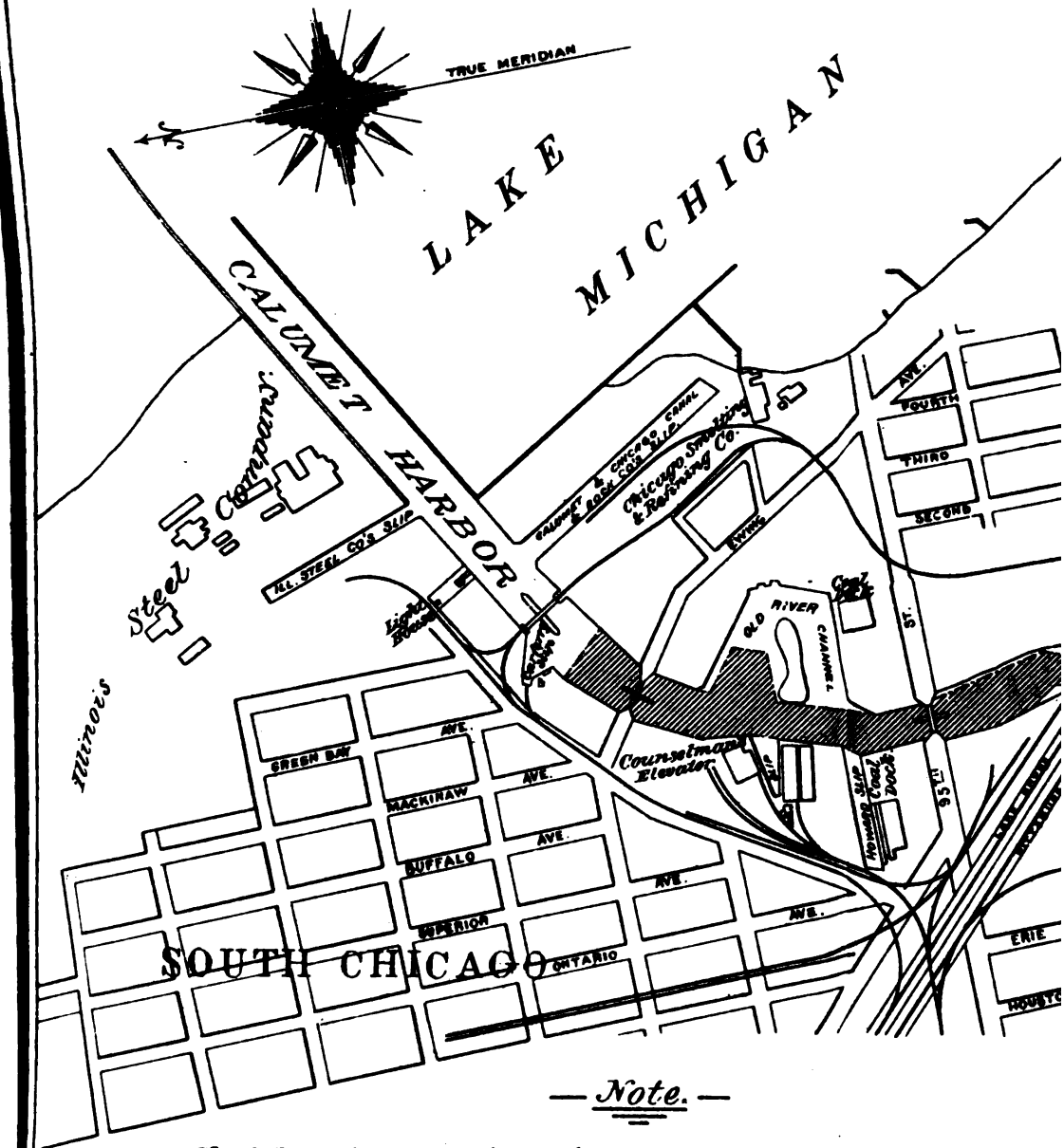
WORK PROPOSED FOR THE ENSUING YEAR.

No work is proposed for the ensuing year, there being no funds available for that purpose.

I am, Major, very respectfully, your obedient servant,

G. A. M. LILJENCRANTZ,
Assistant Engineer.

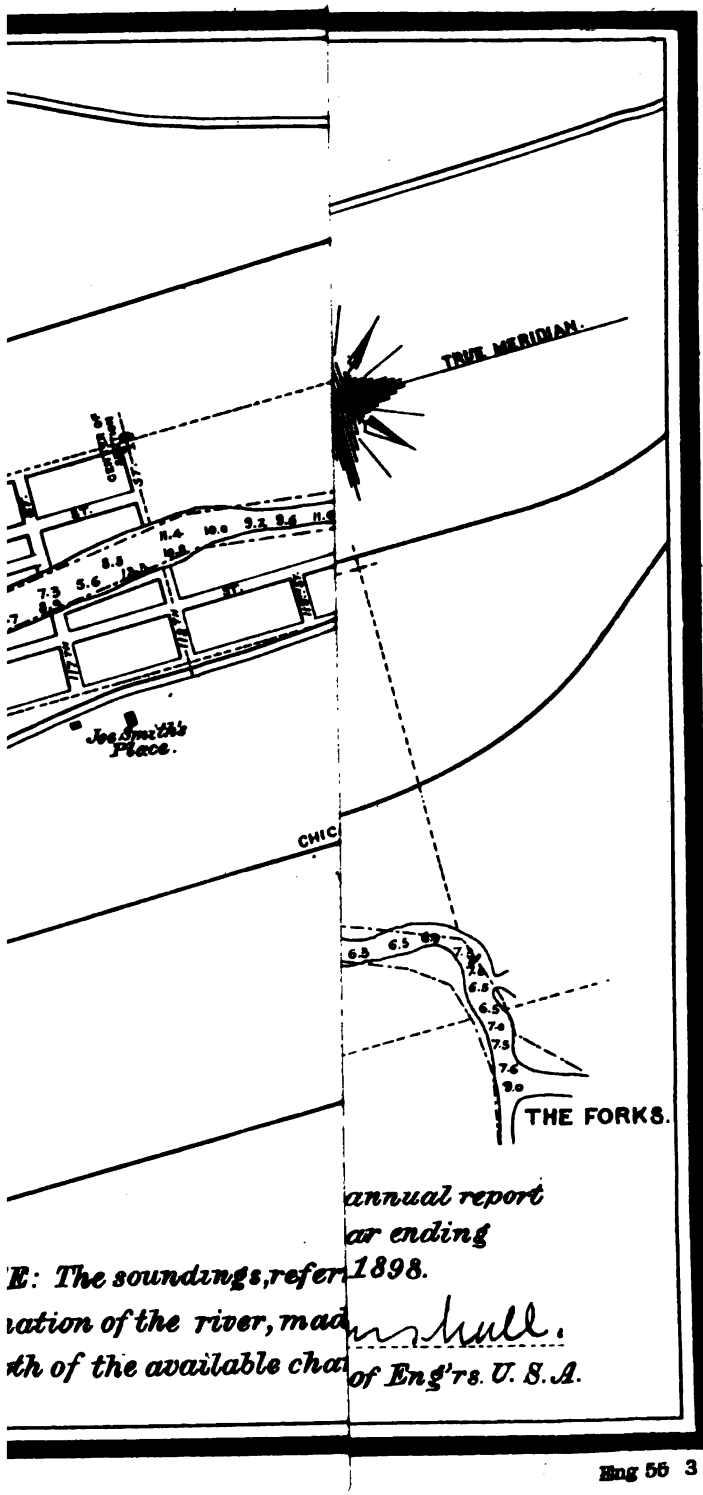
Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.



— *Note.* —

Shaded surface indicates work done under Contract dated Septen

indicates portion of this work done during the fisca



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Below the forks (channel 200 feet wide; contracts 1 to 5, 16 feet deep; contract 6, 20 feet deep).

Contract. No.	Contract. Date.	Contractors.	Period of work. Beginning.	Period of work. Ending.	Amounts dredged. New channel.	Amounts dredged. Redredging.	Total.
					Cu. yds.	*Cu. yds.*	*Cu. yds.*
1	Nov. 5, 1888	W. A. McGillis & Co	May 4, 1889	Dec. 21, 1890	771,737	.....	771,737
2	Dec. 10, 1890	Wheeler & Purcell	Apr. 6, 1891	June 30, 1892	365,719	.....	365,719
3	Oct. 28, 1892	Sheboygan Dredge and Dock Co	May 30, 1893	May 9, 1894	298,902	101,632	400,534
4	a May, 1894	W. A. McGillis & Co	May 24, 1894	Aug. 22, 1894	.....	50,035	50,035
5	Oct., 1894	.....do	Oct. 1, 1894	Aug. 20, 1895	.....	179,195	179,195
6	Sept. 1, 1896	C. E. Mitchell & Co	Sept. 15, 1896	Aug. 31, 1897	320,405	.....	320,405
		Total to end of fiscal year	.....	.....	1,756,763	330,862	2,087,625

Contract. No.	Contract. Date.	Contractors.	Price per cubic yard.	Cost of— New channel.	Cost of— Redredging.	Length of channel improved. New	Length of channel improved. Redredged.
			Cents.			*Feet.*	*Feet.*
1	Nov. 5, 1888	W. A. McGillis & Co	11.75	$90,679.10	.....	12,168	.....
2	Dec. 10, 1890	Wheeler & Purcell	12.25	44,800.58	.....	4,020	2,300
3	Oct. 28, 1892	Sheboygan Dredge and Dock Co	10.7	31,982.52	$10,874.62	3,333	*b* 8,700
4	a May, 1894	W. A. McGillis & Co	10.7	.....	5,353.74	.....	11,826
5	Oct., 1894	.....do	16.5	.....	29,567.16	.....	.....
6	Sept. 1, 1896	C. E. Mitchell & Co	13.25	42,453.66	.....	*c* 10,560	.....
		Total to end of fiscal year	.....	209,915.86	45,795.52	30,078	14,126

a A special agreement.
b This amount being only for "half width," and the other half being done under following contract is not included in the total length redredged.
c New as a "20-foot channel," but where dredging had been previously done to 16 feet.

Above the forks (channel 60 to 70 feet wide; 10 feet deep).

Contract. No.	Contract. Date.	Contractors.	Period of work. Beginning.	Period of work. Ending.	Amounts dredged. New channel.	Amounts dredged. Redredging.	Total.
					Cu. yds.	*Cu. yds.*	*Cu. yds.*
1	Aug. 11, 1887	S. O. Dixon	Sept., 1887	May 5, 1888	76,804	.....	76,804
2	Oct. 31, 1888	Burdick & McMahon	May 7, 1889	Aug. 12, 1889	54,100	10,726	64,826
3	Oct. 28, 1892	Wisconsin Dredge and Dock Co	May 15, 1893	June 5, 1894	19,190	72,772	91,962
4	Oct. 1, 1894	McMahon & Montgomery Co	Oct. 11, 1894	a Dec. 6, 1890	.....	14,924	14,924
		Total to end of fiscal year	.....	.....	150,094	98,422	248,516

Contract. No.	Contract. Date.	Contractors.	Price per cubic yard.	Cost of— New channel.	Cost of— Redredging.	Length of channel improved. New	Length of channel improved. Redredged.
			Cents.			*Feet.*	*Feet.*
1	Aug. 11, 1887	S. O. Dixon	11	$8,448.44	.....	4,900	.....
2	Oct. 31, 1888	Burdick & McMahon	22	11,902.00	$2,359.72	5,600	2,200
3	Oct. 28, 1892	Wisconsin Dredge and Dock Co	13.7	2,629.03	9,969.76	2,900	4,900
4	Oct. 1, 1894	McMahon & Montgomery Co	12.9	.....	1,925.20	.....	1,500
		Total to end of fiscal year	.....	22,979.47	14,254.68	13,400	8,600

a The contract was canceled at the *request of contractors* March 18, 1895.

JJ 5.

IMPROVEMENT OF ILLINOIS RIVER, ILLINOIS.

The object of this improvement is to secure ultimately, in conne with an enlargement of the Illinois and Michigan Canal, or an e alent enlarged channel, a waterway from the southern end of Michigan to the Mississippi River of sufficient capacity for large Mississippi River steamboats, and for military and naval purpose

The present project was adopted in 1880, and contemplates the e sion of the slack water improvement begun by the State of Ill from the mouth of Copperas Creek to the Mississippi River at Gr Ill., a distance of 135 miles. The project includes the constructi two locks, each 350 feet in length of chamber, 75 feet in width, and 7 feet depth at low water over sills, and dredging the channel v necessary to secure that depth of water at low water throughou pools created by the dams.

The locks and dams have been completed and have been in use 1889 and 1893, respectively. One is situated at Lagrange, 79 above the mouth of the Illinois, the other at Kampsville, 31 miles the Mississippi.

The State of Illinois, aided by the United States, has executed of the general project by the construction of locks and dams at I and Copperas Creek, completing, except dredging, that part o project between LaSalle and the mouth of Copperas Creek, a dis of about 90 miles, over which section the State of Illinois collects

In executing this work the United States has expended pri June 30, 1897, $1,344,090.62, including $25,000 from appropriati August 11, 1888, for surveys, and exclusive of $62,359.80 expended a foundation for Copperas Creek Lock, afterwards completed b State of Illinois.

An additional amount of $747,747 was expended by the State o nois at Henry and Copperas Creek.

CONDITION OF THE WORK JUNE 30, 1898.

At the beginning of the fiscal year dredging was in progress Kampsville Lock. Twenty-three thousand five hundred and four yards were dredged between Guilford Bar and the mouth of Mac Creek; 6,386 cubic yards at Twelve Mile Island. The dredges then moved to the pool between Lagrange and Kampsville locks there were dredged at Moores Island 20,445 cubic yards; at New Creek, 36,776 cubic yards; at Wilsons Island, 24,937 cubic yards. funds available were then so near exhausted that on September 5 plant was withdrawn from the work.

Current repairs to plant were made during the year. With few e tions, the dredged channels are reasonably permanent, the excep being at the mouths of certain creeks and tributaries which bri heavy detritus from the bluffs. The dams have no appreciable above mid-stage of the river when the currents are strongest, s all lighter sediment is swept away as well now as before the con tion of the dams. That there has been no appreciable general the pools of the Illinois River is a fact that has been often rem upon by steamboat men and persons interested in the use of the since the construction of the first dam at Henry thirty years ago.

There are now available for work on the Illinois River and in fai dition 3 dredges, 3 steam tenders, 2 quarter boats, 6 dump scows several coal barges, and with sufficient means good progress cou expected.

ow water outside of channels at low water limits the capacity
ıd restricts the output of dredges. It would be economy to
ne powerful dredge, with means of conveying dredged mate-
s and capable of working at high as well as low stages, to
t the dipper dredges now available.
he last season extraordinary low water prevailed in all the
the Mississippi system, yet throughout the season a fair chan-
ing 4 feet in depth, was available in the Illinois River, and it
ly tributary of the Mississippi upon which navigation was
ally suspended. On this river traffic in volume exceeded
f the previous year, when a good navigable stage existed
the year, the tonnage of boats and barges having increased
65 tons in 1897 to 362,676 tons in 1898. Much, if not the
t, of the traffic on this river passes neither of the locks, but
he pools.
ring and use of bottom lands and the leveeing of the same to
m against overflow is rapidly increasing, and the wisdom of
this natural waterway will become more and more apparent
s made of it as the channel is improved. This same process
lamation, however, has resulted in a demand for the removal
s and dams and the dredging of a deep channel instead,
in the interest of navigation. This demand does not pro-
parties engaged in commerce by water, but from the landed
siring the dredged material deposited upon the banks in the
ees to protect against overflow property now annually sub-

ging of a practicable channel now necessary to the comple-
adopted method of improvement must be done under any of
d plans, and it is not apparent on what grounds appropria-
is part of the project may be consistently opposed by any of
parties interested in the Illinois River work.

Disbursements, fiscal year 1898.

.....	$9,499.03
.....	1,455.63
ir of property and plant.....	337.51
nce and office	3,035.02
.....	14,327.19

Appropriations.

available from previous appropriations	$38,337.81
0.....	110,000.00
81	250,000.00
82	175,000.00
.....	100,000.00
86	112,500.00
1888	200,000.00
ion, September 29, 1890	200,000.00
2.....	100,000.00
1894	35,000.00
.....	40,000.00
	1,360,837.81
n all other sources.....	535.40
.....	1,361,373.21
June 30, 1898	1,358,417.81
e unexpended June 30, 1898.....	2,955.40

Money statement.

July 1, 1897, balance unexpended	$17,282.59
June 30, 1898, amount expended during fiscal year	14,327.19
July 1, 1898, balance unexpended	2,955.40
Amount (estimated) required for completion of existing project	357,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	357,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Arrival and departure of steamboats and barges at St. Louis, Mo., via Illinois River, calendar year 1897.

Month.	Arrivals.	Departures.	Receipts.	Shipments.
January	4	2	45	.....
February	3	4	70	.....
March	12	7	4,960	790
April	16	12	14,410	875
May	13	15	2,980	550
June	16	13	4,040	975
July	17	10	4,210	775
August	18	11	3,580	340
September	11	10	1,245	1,210
October	12	10	1,410	985
November	7	8	1,180	565
December	1	.....	.....	.....
Total	130	102	38,130	7,065

REPORT OF MR. C. V. BRAINARD, ASSISTANT ENGINEER.

KAMPSVILLE, ILL., *June 30, 1898.*

MAJOR: I have the honor to submit the following report of operations upon improving Illinois River for the fiscal year ending June 30, 1898:

At the beginning of the fiscal year dredging was in progress between the mouth of Macoupin Creek and Guilford Bar. A channel 5,000 feet long, 130 feet wide, and 7 feet deep, was completed through this distance, 53,265 cubic yards of sand and mud being moved, of which 26,761 cubic yards was done in the previous fiscal year.

Twelve-Mile Island (18 miles below Kampsville Lock).—On July 21 the dredges were moved to the head of Twelve-Mile Island, to widen the channel dredged there in 1895, between the mouth of Otter Creek and the head of the island. One cut was made along the east side of the former channel, making it 130 feet wide, moving 6,386 cubic yards of sand. This work was discontinued because of the rapidly rising river, the stage being too high to hold the dredges in position, and the fleet towed to Moores Island, about 70 miles up the river and 1 mile below Lagrange Lock.

Moores Island (1 mile below Lagrange Lock).—A cut 2,200 feet long, 105 feet wide, and 7 feet deep, was dredged here, 20,445 cubic yards of clay being moved.

New Camp Creek (3 miles below Lagrange Lock).—This dredged channel is 2,300 feet long and the same width and depth as at Moores Island. About 1,460 linear feet of the west cut of this channel was cast to one side, the water being too shoal to operate the towboats and scows. Thirty-six thousand seven hundred and seventy-eight cubic yards of sand was removed from the dredged channel.

Wilsons Island (5 miles below Lagrange Lock).—A channel 2,275 feet long was made at this point, the same width and depth as at Moores Island, by the removal of 24,937 cubic yards of mud.

The funds for improving Illinois River being exhausted, work was ordered stopped upon the completion of this channel. On September 25 one dredge was towed to Lagrange Lock to fill above the dam, and the other two, with office boat, quarter boats, scows, and barges, were towed to Kampsville Lock.

During the work the following repairs were made to the dredges:

Apache.—Set out friction blocks of hoisting drum, put two new stud bolts in boxings of countershaft of hoisting engines, and repaired crack in hoisting drum.

No. 1.—Two new spuds and a pair of new friction wheels on the crane.
No. 2.—One new spud, repaired broken crown wheel, afterwards replacing new one, and a new shaft for the swinging engines.
close of the dredging there was a navigable channel exceeding 4 feet in om Copperas Creek Lock to the mouth of the river.
the calendar year 1897 there was moved 178,491 cubic yards of sand and mud. for this was $15,326.88, including all repairs, supplies, labor, and watchmen, ents per cubic yard. This does not include cost of superintendence.
ry respectfully, your obedient servant,

C. V. BRAINARD,
Assistant Engineer.

T. L. MARSHALL,
Corps of Engineers.

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ns of (tridaily) readings of the upper gauge at Copperas Creek Lock, 1897.

[Plane of reference: Lower miter sill.]

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
...	12.80	17.13	17.53	21.30	16.50	13.10	14.07	12.13	11.90	11.80	11.90	12.20
..	13.20	17.00	17.50	21.30	16.50	13.00	14.00	12.07	11.90	11.80	12.00	12.20
...	13.80	16.93	17.43	21.30	16.47	12.87	13.90	12.10	11.90	11.80	12.00	12.20
...	14.30	16.67	17.20	21.20	16.33	12.80	13.80	12.10	11.97	11.80	11.87	12.10
...	14.93	16.50	17.30	21.07	16.20	12.80	13.80	12.20	11.90	11.80	11.83	12.10
...	15.73	16.30	17.53	20.87	16.20	12.70	13.70	12.13	11.90	11.80	12.00	12.10
...	16.57	16.40	17.40	20.50	16.17	12.70	13.67	12.00	11.90	11.80	12.10	12.10
...	16.90	16.40	17.40	20.20	16.10	12.60	13.60	12.00	11.90	11.80	12.20	12.10
...	17.13	16.57	17.53	19.97	16.00	12.60	13.50	12.00	11.90	11.80	12.20	12.10
...	17.37	16.70	17.73	19.70	15.97	12.60	13.27	12.00	11.90	11.80	12.07	11.90
...	17.63	16.70	17.93	19.40	15.77	12.50	13.10	12.00	11.90	11.80	12.03	11.70
...	17.90	16.57	18.13	19.03	15.67	12.50	13.17	12.00	11.90	11.80	12.20	11.70
...	18.13	16.37	18.40	19.00	15.50	12.40	13.00	12.00	11.90	11.80	12.20	11.70
...	18.23	16.30	18.80	18.67	15.37	12.40	12.87	11.93	11.90	11.80	12.20	11.70
...	18.23	16.30	19.03	18.57	15.20	12.30	12.70	11.80	11.80	11.80	12.20	11.67
...	18.10	16.30	19.30	18.36	15.03	12.17	12.80	11.90	11.80	11.80	12.20	11.50
...	18.00	16.30	19.53	18.10	14.93	12.00	12.77	12.00	11.90	12.03	12.30	11.50
...	18.07	16.40	19.63	17.90	14.80	12.03	12.70	12.00	11.83	11.90	12.30	11.50
...	18.10	16.43	19.90	17.77	14.63	12.20	12.73	12.00	11.90	11.90	12.30	11.50
...	18.13	16.50	20.20	17.57	14.50	12.67	12.80	12.00	11.90	11.90	12.30	11.50
...	18.23	16.50	20.43	17.36	14.37	12.83	12.77	11.90	11.90	11.90	12.20	11.40
..	18.30	16.57	20.90	17.17	14.17	13.03	12.70	11.90	11.90	11.90	12.20	11.40
..	18.20	16.73	21.20	17.10	14.00	13.24	12.70	11.90	11.90	11.90	12.20	11.40
..	18.20	16.97	21.60	17.10	13.83	13.40	12.70	11.90	11.90	11.90	12.20	11.40
..	18.10	17.13	21.77	17.07	13.73	13.63	12.70	11.90	11.80	11.90	12.33	11.40
..	18.00	17.37	21.80	17.00	13.67	13.83	12.70	11.90	11.80	11.90	12.43	11.40
..	17.90	17.57	21.80	16.87	13.60	13.90	12.60	11.90	11.80	11.90	12.60	11.40
..	17.73	17.73	21.80	16.77	13.53	14.00	12.60	11.90	11.80	11.90	12.50	11.40
..	17.57	.....	21.70	16.70	13.37	14.00	12.47	11.90	11.80	11.90	12.37	11.40
..	17.47	.....	21.57	16.56	13.23	14.00	12.40	11.90	11.80	11.90	12.27	11.40
..	17.27	.....	21.40	.....	13.10	.....	12.30	11.90	.....	11.90	.....	11.40
	17.11	16.69	19.40	18.71	14.98	12.89	13.03	11.98	11.87	11.85	12.19	11.69

Means of (tridaily) readings of the lower gauge at Copperas Creek Lock, 1897.

[Plane of reference: Lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	9.43	16.20	17.23	(a)	16.30	11.87	12.97	8.97	6.80	6.70	6.90	7.97
2	9.77	15.97	17.10	(a)	16.20	11.70	12.87	8.80	6.80	6.70	7.00	7.87
3	11.50	15.87	17.07	(a)	16.17	11.60	12.87	8.77	6.80	6.70	6.90	7.80
4	12.63	15.63	17.00	(a)	16.03	11.37	12.80	8.37	6.87	6.70	6.83	7.70
5	13.67	15.47	17.03	(a)	16.00	11.20	12.70	8.26	6.90	6.70	6.80	8.00
6	14.73	15.30	17.23	(a)	15.97	10.93	12.70	8.00	6.90	6.70	6.90	8.00
7	15.60	15.40	17.40	(a)	15.87	10.80	12.67	7.97	6.90	6.70	7.00	7.87
8	16.20	15.40	17.40	(a)	15.80	10.60	12.57	7.87	6.90	6.70	7.10	7.80
9	16.73	15.53	17.47	(a)	15.70	10.30	12.40	7.76	6.90	6.70	7.23	7.70
10	17.10	15.60	17.53	(a)	15.57	10.13	12.20	7.60	6.90	6.70	7.27	7.73
11	17.40	15.60	17.80	(a)	15.40	9.97	12.10	7.50	6.90	6.70	7.20	8.20
12	17.63	15.60	18.03	18.97	15.37	9.87	12.13	7.47	6.90	6.70	7.30	8.20
13	17.77	15.70	18.27	18.80	15.20	9.80	11.87	7.40	6.80	6.70	7.40	8.10
14	17.87	15.83	18.57	18.57	15.07	9.57	11.40	7.27	6.80	6.70	7.43	8.23
15	17.90	15.90	18.83	18.40	14.87	9.30	11.00	7.20	6.70	6.70	7.50	8.17
16	17.90	15.90	(a)	18.17	14.63	9.07	11.00	7.10	6.80	6.70	7.50	7.87
17	17.90	15.93	(a)	17.97	14.53	8.87	10.70	6.97	6.90	6.90	7.50	7.93
18	18.00	16.00	(a)	17.76	14.40	8.93	10.63	6.87	6.83	6.87	7.50	8.20
19	18.00	16.00	(a)	17.57	14.23	9.20	10.67	6.90	6.80	6.80	7.50	8.20
20	18.10	16.10	(a)	17.37	14.07	9.57	10.37	6.80	6.80	6.80	7.50	8.20
21	18.10	16.10	(a)	17.16	13.87	9.90	10.28	6.80	6.80	6.80	7.50	8.20
22	18.10	16.20	(a)	17.10	13.77	10.33	10.10	6.77	6.80	6.80	7.50	8.20
23	18.10	16.43	(a)	16.90	13.57	10.80	10.00	6.70	6.80	6.80	7.50	8.20
24	17.97	16.70	(a)	16.90	13.33	11.13	10.13	6.70	6.77	6.80	7.50	8.20
25	17.77	16.93	(a)	16.90	13.17	11.80	10.20	6.70	6.70	6.80	7.63	8.20
26	17.56	17.17	(a)	16.80	12.97	12.10	10.00	6.80	6.70	6.80	8.03	8.20
27	17.43	17.33	(a)	16.67	12.80	12.33	9.80	6.80	6.70	6.80	8.14	8.20
28	17.13	17.37	(a)	16.57	12.63	12.60	9.80	6.80	6.70	6.83	8.20	8.20
29	16.94	.....	(a)	16.50	12.43	12.80	9.60	6.80	6.70	6.90	8.17	8.20
30	16.77	.....	(a)	16.40	12.27	12.83	9.37	6.80	6.70	6.90	8.07	8.20
31	16.43	.....	(a)	.....	12.07	.....	9.10	6.80	.....	6.90	.....	8.20
Means.	16.39	16.04	.....	.....	14.52	10.71	11.19	7.36	6.81	6.76	7.42	8.06

a Water level above the top of the gauge.

Means of (tridaily) readings of the upper gauge at Lagrange Lock, 1897.

[Plane of reference: Lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	15.93	18.83	19.50	24.65	20.13	16.75	16.77	15.78	15.02	15.35	15.40	15.35
2	16.02	18.65	19.57	25.00	20.10	16.75	16.82	15.72	15.00	15.35	15.40	15.30
3	17.40	18.52	19.60	25.10	20.10	16.72	16.95	15.72	15.03	15.35	15.40	15.30
4	17.92	18.43	19.60	25.08	20.10	16.68	16.92	15.70	15.10	15.40	15.40	15.27
5	18.52	18.35	19.95	25.00	20.10	16.60	17.20	15.68	15.17	15.40	15.40	15.32
6	18.88	18.38	20.20	24.95	20.02	16.55	17.18	15.58	15.22	15.40	15.40	15.20
7	19.07	18.40	20.33	24.70	19.93	16.48	17.08	15.52	15.27	15.40	15.45	15.20
8	19.18	18.38	20.42	24.45	19.80	16.40	16.98	15.50	15.33	15.40	15.50	15.20
9	19.25	18.33	20.50	24.20	19.68	16.35	16.88	15.43	15.35	15.40	15.50	15.22
10	19.22	18.28	20.65	24.03	19.50	16.27	16.80	15.40	15.35	15.40	15.50	15.25
11	19.27	18.23	20.85	23.80	19.35	16.20	17.27	15.33	15.35	15.40	15.55	15.30
12	19.42	18.18	21.00	23.58	19.08	16.18	17.10	15.30	15.35	15.40	15.58	15.38
13	19.47	18.18	21.18	23.30	18.80	16.13	16.83	15.30	15.35	15.43	15.60	15.40
14	19.67	18.32	21.37	23.05	18.45	16.05	16.72	15.23	15.35	15.45	15.60	15.42
15	19.95	18.55	21.52	22.80	18.25	15.97	16.65	15.20	15.30	15.40	15.60	15.38
16	20.10	18.62	21.70	22.52	18.13	15.93	16.62	15.20	15.32	15.40	15.60	15.30
17	20.38	18.68	21.87	22.25	18.00	15.85	16.50	15.15	15.33	15.40	15.60	15.28
18	20.52	18.80	22.12	22.08	17.85	15.78	16.42	15.13	15.30	15.40	15.57	15.23
19	20.58	18.92	22.40	21.77	17.75	15.75	16.33	15.10	15.30	15.40	15.45	15.20
20	20.60	19.03	22.65	21.57	17.63	15.85	16.30	15.07	15.33	15.40	15.30	15.20
21	20.65	19.12	22.78	21.40	17.53	15.93	16.22	15.05	15.35	15.40	15.30	15.20
22	20.65	19.22	22.98	21.13	17.48	16.00	16.17	15.08	15.35	15.37	15.28	15.25
23	20.65	19.33	23.15	20.95	17.43	16.02	16.02	15.05	15.35	15.38	15.25	15.22
24	20.55	19.35	23.35	20.92	17.35	16.37	16.15	15.02	15.33	15.40	15.23	15.20
25	20.32	19.40	23.65	20.88	17.25	16.52	16.38	15.05	15.30	15.40	15.20	15.20
26	20.05	19.40	23.83	20.70	17.17	16.47	16.27	15.05	15.35	15.40	15.25	15.20
27	19.85	19.40	23.95	20.55	17.20	16.50	16.20	15.05	15.40	15.40	15.35	15.20
28	19.73	19.47	24.05	20.40	17.20	16.58	16.13	15.05	15.38	15.40	15.40	15.20
29	19.63	.....	24.10	20.30	17.10	16.65	16.00	15.05	15.35	15.40	15.37	15.20
30	19.37	.....	24.10	20.23	16.95	16.70	15.93	15.05	15.35	15.40	15.35	15.20
31	19.08	.....	24.37	.....	16.83	.....	15.85	15.05	.....	15.40	.....	15.25
Means.	19.42	18.74	21.85	22.71	18.46	16.30	16.57	15.28	15.29	15.40	15.43	15.26

Means of (tridaily) readings of the lower gauge at Lagrange Lock, 1897.

[Plane of reference: Lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.90	18.10	18.87	24.43	19.78	13.85	13.15	10.45	8.20	7.85	7.92	9.00
2	11.67	17.85	18.93	24.80	19.75	13.67	13.35	10.37	8.15	7.80	7.95	8.97
3	15.27	17.70	18.97	24.92	19.78	13.45	13.67	10 07	8.13	7.80	7.95	8.90
4	17.07	17.58	19.03	24.93	19.80	13.25	13.58	10.03	8.12	7.80	7.95	8.85
5	17.70	17.47	19.50	24.85	19.77	13.05	14.07	10.02	8.07	7.80	7.95	8.70
6	18.13	17.52	19.75	24.75	19.67	12.85	14.28	9.88	8.08	7.78	7.95	8.73
7	18.38	17.55	19.93	24.55	19.56	12.63	14.07	9.68	8.07	7.75	8.05	8.70
8	18.56	17.52	20.00	24.30	19.45	12.35	13.83	9.55	7.98	7.73	8.15	8.67
9	18.48	17.43	20.08	24.07	19.30	12.15	13.55	9.35	8.05	7.73	8.17	8.65
10	18.48	17.38	20.25	23.85	19.10	11.93	13.35	9.15	8.05	7.80	8.20	8.70
11	18.63	17.22	20.45	23.60	18.88	11.70	14.27	8.97	8.00	7.80	8.25	8.80
12	18.75	17.13	20.58	23.42	18.58	11.57	13.97	8.92	8.00	7.80	8.28	9.00
13	18.88	17.15	20.77	23.07	18.27	11.42	13.50	8.73	8.00	7.85	8.30	9.17
14	19.08	17.42	20.97	22.85	17.93	11.25	13.20	8.63	8.02	7.90	8.35	9.22
15	19.30	17.75	21.13	22.60	17.58	11.05	12.88	8.45	8.00	7.90	8.40	9.10
16	19.43	17.85	21.40	22.33	17.35	10.85	12.63	8.42	7.95	7.90	8.43	8.97
17	19.68	17.93	21.65	22.05	17.07	10.65	12.40	8.37	7.90	7.90	8.38	8.88
18	20.00	18.10	21.87	21.85	16.77	10.45	12.13	8.27	7.85	7.90	8.35	9.00
19	20.08	18.23	22.12	21.58	16.48	10.28	11.97	8.16	7.85	7.90	8.78	9.00
20	20.15	18.37	22.35	21.32	16.18	10.50	11.83	8.07	7.88	7.90	8.85	9.00
21	20.20	18.42	22.57	21.15	15.93	10.70	11.68	8.05	7.90	7.90	8.75	9.00
22	20.20	18.52	22.73	20.88	15.65	10.85	11.52	8.08	7.90	7.87	8.65	9.00
23	20.25	18.62	22.90	20.70	15.45	11.18	11.32	8.00	7.95	7.88	8.52	9.00
24	20.15	18.70	23.12	20.67	15.25	11.90	11.53	8.02	8.00	7.90	8.60	9.00
25	19.87	18.75	23.40	20.58	15.03	12.47	12.42	8.08	8.00	7.90	8.75	9.00
26	19.52	18.70	23.58	20.43	14.77	12.42	12.18	8.13	7.98	7.90	8.87	9.00
27	19.32	18.70	23.72	20.27	14.75	12.60	11.73	8.23	7.87	7.90	8.95	8.98
28	19.23	18.75	23.82	20.10	14.80	12.72	11.40	8.20	7.85	7.95	9.05	8.95
29	19.13	.....	23.90	19.98	14.63	12.88	11.05	8.20	7.85	7.93	9.07	8.90
30	18.68	.....	23.97	19.88	14.40	13.05	10.90	8.20	7.85	7.90	9.05	8.93
31	18.30	.....	24.10	.....	14.05	.....	10.68	8.20	.....	7.90	.....	9.02
Means	18.50	17.95	21.50	22.49	17.28	11.99	12.65	8.80	7.98	7.86	8.43	8.93

Means of (tridaily) readings of the upper gauge at Kampsville Lock, 1897.

[Plane of reference: Lower miter sill.]

Day.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	15.90	18.12	18.30	25.55	25.70	16.95	16.85	15.95	16.10	16.00	16.05	15.80
2	16.53	18.03	18.40	26.22	25.87	16.88	16.85	15.93	16.10	16.00	16.00	15.58
3	18.17	17.95	18.50	26.92	25.95	16.78	16.87	15.85	16.10	16.00	15.95	15.40
4	18.85	17.92	18.57	27.30	25.80	16.70	16.90	15.90	16.10	16.00	15.73	15.30
5	20.20	17.90	19.52	27.60	25.53	16.63	16.95	16.05	16.05	15.95	16.03	15.38
6	20.78	18.05	19.90	27.75	25.13	16.58	17.30	15.98	16.05	15.95	16.00	15.42
7	20.63	18.08	20.57	27.60	24.69	16.50	17.05	15.88	16.05	16.00	16.05	15.48
8	19.93	18.07	20.67	27.30	24.15	16.45	16.98	15.80	16.05	15.95	16.05	15.45
9	18.97	17.90	20.40	27.02	23.65	16.38	16.90	15.75	16.05	16.00	16.03	15.45
10	18.48	17.90	20.20	27.00	23.20	16.35	16.83	15.70	16.00	16.00	16.00	15.55
11	18.40	17.83	19.97	26.90	22.60	16.30	16.85	15.63	16.00	16.00	16.00	15.52
12	18.40	17.80	19.95	26.68	21.95	16.23	16.98	15.55	16.00	16.00	16.05	15.50
13	18.42	17.83	19.95	26.37	21.17	16.20	16.88	15.55	16.00	16.00	16.10	15.57
14	18 55	17.92	20.07	26.03	20.38	16.15	16.78	15.50	16.05	15.93	16.07	15.63
15	18.60	18.00	20.22	25.65	19.80	16.10	16.70	15.48	16.08	16.00	16.15	15.53
16	18.65	18.05	20.40	25.28	19.28	16.03	16.63	15.40	16.10	15.90	16.15	15.62
17	18.88	18.10	20.65	24.93	18.80	16.00	16.53	15.40	16.05	15.93	16.15	15.58
18	19.07	18.15	20.90	24.65	18.35	15.95	16.45	15.40	16.00	15.95	16.13	15.43
19	19.20	18.15	21.23	24.35	17.98	15.90	16.40	15.38	15.95	15.98	16.10	15.45
20	19.33	18.15	21.55	24.20	17.75	15.90	16.33	15.30	15.92	16.00	16.15	15.45
21	19.35	18.20	21.85	24.07	17.58	15.90	16.23	15.32	15.90	16.05	16.17	15.45
22	19.38	18.25	22.15	24.00	17.48	16.00	16.20	15.40	16.02	16.03	16.20	15.45
23	19.42	18.30	22.45	23.98	17.45	16.00	16.10	15.35	16.03	16.00	16.20	15.45
24	19.38	18.30	22.75	24.00	17.38	16.40	16.27	15.70	15.95	16.00	16.15	15.45
25	19.22	18.30	23.05	24.12	17.28	16.90	17.15	16.00	16.00	16.00	16.03	15.45
26	19.12	18.30	23.40	24.10	17.13	16.75	16.97	16.10	16.00	16.03	16.15	15.45
27	18.75	18.25	23.73	24.17	17.12	16.68	16.55	16.10	16.05	16.05	16.18	15.40
28	18.52	18.25	24.03	24.35	17.15	16.65	16.35	16.10	16.00	16.05	16.00	15.40
29	18.30	.....	24.35	24.80	17.15	16.85	16.15	16.10	15.93	16.00	16.00	15.40
30	18.25	.....	24.78	25.30	17.08	16.85	16.08	16.10	15.93	16.00	15.93	15.40
31	18.15	.....	24.93	.....	16.98	.....	16.00	16.10	.....	16.00	.....	15.40
Means	18.83	18.07	21.21	25.60	20.57	16.40	16.65	15.73	16.02	15.99	16.06	15.48

Means of (tridaily) readings of the lower gauge at Kampsville Lock, 1897.

[Plane of reference: Lower miter sill.]

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.10	16.08	16.82	25.30	25.60	13.65	14.70	12.48	7.83	6.90	7.47	8.75
2	11.07	15.98	16.97	25.93	25.77	13.43	14.95	12.22	7.75	6.93	7.02	8.45
3	16.02	15.78	17.30	26.68	25.85	13.23	15.57	12.03	7.68	6.90	6.73	8.27
4	18.20	15.68	17.52	27.10	25.70	13.05	15.40	11.82	7.58	6.85	6.70	8.10
5	19.90	15.58	18.90	27.40	25.43	12.92	14.85	11.95	7.50	6.75	6.93	8.07
6	20.55	15.87	19.35	27.55	25.03	12.85	15.25	11.80	7.45	6.78	6.92	7.98
7	20.33	16.08	20.19	27.38	24.53	12.73	15.02	11.35	7.40	6.73	7.13	7.85
8	19.57	16.10	20.25	27.10	23.95	12.55	14.70	11.10	7.33	6.65	7.37	7.85
9	18.35	15.92	19.90	26.82	23.45	12.38	14.30	10.90	7.30	6.85	7.40	7.87
10	17.40	15.60	19.67	26.80	23.00	12.15	13.90	10.73	7.37	6.90	7.33	8.13
11	16.93	15.53	19.40	26.70	22.40	11.95	13.90	10.55	7.47	6.90	7.23	8.10
12	16.85	15.45	19.40	26.48	21.75	11.75	13.97	10.40	7.35	6.85	7.27	8.10
13	16.85	15.50	19.40	26.17	20.92	11.55	13.60	10.35	7.20	6.83	7.40	8.45
14	16.93	15.77	19.45	25.82	20.10	11.30	13.20	10.38	7.18	6.62	7.42	8.55
15	17.03	15.87	19.60	25.45	19.45	11.10	12.95	10.33	7.10	6.72	7.65	8.27
16	17.20	16.00	19.80	25.08	18.88	11.00	12.75	10.20	7.25	6.90	7.90	8.55
17	17.65	16.13	20.07	24.73	18.33	10.93	12.55	10.18	7.25	6.92	7.62	8.45
18	18.10	16.25	20.38	24.45	17.83	10.82	12.38	10.08	7.05	7.00	7.70	8.75
19	18.40	16.35	20.73	24.15	17.30	10.70	12.30	9.95	7.12	6.93	7.68	8.67
20	18.60	16.40	21.07	24.00	16.80	10.70	12.20	9.83	6.90	6.85	7.85	8.50
21	18.65	16.50	21.42	23.87	16.33	10.75	11.95	9.72	6.87	6.82	7.92	8.45
22	18.68	16.70	21.75	23.80	15.90	11.05	11.85	9.55	6.95	6.85	8.00	8.45
23	18.67	16.90	22.08	23.78	15.60	11.55	11.70	9.29	6.90	6.88	7.85	8.45
24	18.60	17.00	22.38	23.80	15.23	12.45	12.17	8.93	6.95	6.92	7.95	8.45
25	18.25	17.03	22.70	23.92	14.98	13.80	14.25	8.78	7.02	6.97	8.08	8.40
26	18.05	16.95	23.05	23.90	14.65	13.88	15.43	8.72	7.08	6.95	8.00	8.40
27	17.55	16.88	23.38	23.97	14.48	13.90	15.95	8.63	7.00	6.93	8.03	8.35
28	17.29	16.80	23.73	24.15	14.40	13.92	15.63	8.35	6.95	7.00	8.28	8.32
29	16.90	.....	24.05	24.67	14.40	13.43	14.27	8.18	6.87	6.95	8.20	8.30
30	16.72	.....	24.38	25.20	14.25	14.65	13.20	8.05	6.88	6.90	8.23	8.30
31	16.32	.....	24.68	.....	13.93	.....	12.75	7.87	.....	6.95	.....	8.40
Means..	17.47	16.17	20.64	25.40	19.55	12.34	13.79	10.15	7.22	6.87	7.57	8.33

JJ 6.

OPERATING AND CARE OF LAGRANGE AND KAMPSVILLE LOCKS, ILLINOIS RIVER, AND APPROACHES THERETO.

These locks and dams have been operated and maintained under the indefinite appropriation provided for in section 4 of the river and harbor act of July 5, 1884.

Lagrange Lock and Dam.—These works were operated and maintained in good order during the year. The drift was kept cleared from the dam; the lock gates were calked, painted, and repaired; guide piles were placed above and below the lock entrances; 1,470 cubic yards of filling were placed above the dam, and low places about the grounds filled in and the buildings and plant kept in order.

Kampsville Lock and Dam.—Drift was cleared from the dam, clumps of guide piles driven at entrances to the lock, 400 cubic yards sediment were removed from the lock and filling was placed above the dam and on upper side of east abutment, 4,470 cubic yards earth and 35 cubic yards riprap and gravel being used for the purpose.

Current repairs were made to lock houses and buildings, 1,650 feet plank sidewalk built, and 500 cubic yards filling placed about the grounds.

Two new dump scows were built and repairs made to boats and plant.

The river was unusually low during the season, but nevertheless there was a small increase in the tonnage passing the locks over that passing in 1897.

Money statements.

LAGRANGE LOCK.

July 1, 1897, balance unexpended (outstanding)	$496.10
July 1, 1897, allotment for fiscal year	10,000.00
Total	10,496.10
June 30, 1898, amount expended during fiscal year	6,344.37
July 1, 1898, balance unexpended	4,151.73
July 1, 1898, outstanding liabilities	437.50
July 1, 1898, balance available	3,714.23

KAMPSVILLE LOCK.

July 1, 1897, balance unexpended (outstanding)	$480.60
July 1, 1897, allotment for fiscal year	10,000.00
Total	10,480.60
June 30, 1898, amount expended during fiscal year	7,223.31
July 1, 1898, balance unexpended	3,257.29
July 1, 1898, outstanding liabilities	798.44
July 1, 1898, balance available	2,458.85

Disbursements, fiscal year 1898.

Lagrange Lock, Illinois River:		
Operating and caring for lock	$4,869.62	
Dredging	301.18	
Property and plant	358.86	
Care and repair of property and plant	636.51	
Care and repair of Lagrange Dam	178.20	
		$6,344.37
Kampsville Lock, Illinois River:		
Operating and caring for lock	4,098.71	
Dredging	102.48	
Property and plant	728.03	
Care and repair of property and plant	1,871.76	
Care and repair of Kampsville Dam	422.33	
		7,223.31
Total		13,567.68

Itemized statement of expenses made from appropriation for operating and care of canals and other works of navigation, indefinite, applied to Lagrange Lock, Illinois River.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1897.				
July 3	1	Hired men	Services	$440.10
3	2	....do	....do	56.00
Aug. 5	1	....do	....do	437.20
5	2	J. H. Reische	Hardware, etc	10.44
5	3	Schmoldt Bros	Lumber and lime	45.07
5	4	Anchor Line Store	Paint, nails, etc	89.40
24	5	Standard Oil Co	Oil	5.46
Sept. 7	1	Hired men	Services	444.38
20	2	Maj. W. L. Marshall	Mileage	22.00
20	3	Jefford & Bro	Coal	160.50
Oct. 5	1	Hired men	Services	436.25
5	2	....do	....do	109.20
13	3	....do	....do	65.77
Nov. 3	1	....do	....do	470.00
3	2	Jacob Diehl	....do	1.67
10	3	W. C. Perry	Piling	171.27
17	4	A. K. Shepard, jr	Traveling expenses	10.04
Dec. 2	1	Hired men	Services	438.75
7	2	B. A. McCoy	Subsistence stores	4.60
16	3	Standard Oil Co	Oil	5.46
30	4	John Madox	Services	5.00

Itemized statement of expenses made from appropriation for operating and care of can and other works of navigation, etc.—Continued.

Date.	No. of voucher.	To whom paid.	For what paid.	Amou
1898.				
Jan. 3	1	Hired men	Services	42
6	2	R. M. Barry	Beef and bread	
15	3	Wagner Palace Co	Transportation	
Feb. 4	1	Hired men	Services	45
15	2	W. C. Perry	Timber	
18	3	Andrew J. Boss	Bolts, nuts, etc	3
Mar. 4	1	Hired men	Services	41
9	2	Frank Tozier	Traveling expenses	
9	3	C. V. Brainard	do	1
25	4	Marcus J. Woods	Services	1
Apr. 7	1	Hired men	do	44
May 3	1	do	do	43
7	2	Wieder Paint Co	Paint, oil, etc	23
10	3	Standard Oil Co	Oil	
June 1	1	Hired men	Services	42
9	2	C. V. Brainard	Reimbursement	
		Total		6,34

Itemized statement of expenses from appropriation for operating and care of canals other works of navigation, indefinite, applied to Kampsville Lock, Illinois River.

Date.	No. of voucher.	To whom paid.	For what paid.	Amou
1897.				
July 3	1	Hired men	Services	$44
10	2	Phil. Ammott	Hinges and screws	
10	3	Rose & Son	Paint	
10	4	J. A. Kamp	Paint, nails, and wicks	
17	5	Thomas Hough	Lumber	2
25	6	Mrs. B. Sutter	White lead	
Aug. 5	1	Hired labor	Services	44
5	2	Martin H. Kendig	Lockage blanks	
5	3	J. A. Kamp	White lead	
24	4	Standard Oil Co	Oil	
Sept. 3	1	Hired men	Services	43
15	2	Joseph Hayne	Lumber	5
15	3	C. V. Brainard	Traveling expenses	
Oct. 5	1	Hired men	Services	52
13	2	do	do	14
15	3	Thomas Hough	Lumber	3
Nov. 3	1	Hired men	Services	54
10	2	W. C. Perry	Piling	24
10	3	Mrs. B. Sutter	Whitewash brushes	
10	4	John Siebermann	Ice	
10	5	Queen Renoad	Labor	
17	6	Rose & Son	Subsistence stores	1
17	7	Fred M. Schumann	Milk	
20	8	Henry Rose	Services	
Dec. 12	1	Hired men	do	53
12	2	George Gramberg	do	4
12	3	The Carlinville Coal Co	Coal	3
30	4	Henry Edwards	Subsistence stores	
1898.				
Jan. 3	1	Hired men	Services	49
6	2	Anchor Line Store	Machine die	
6	3	Daniel Bushnell	Dynamite, etc	
7	4	George F. Renoad	Services	4
Feb. 4	1	Hired men	do	58
Mar. 2	1	do	do	59
11	2	Maj. W. L. Marshall	Mileage	2
25	3	Henry Rose	Services	
Apr. 7	1	Hired men	do	58
7	2	Rose & Son	Subsistence stores	
7	3	Evens & Howard Fire Brick Co	Fire brick and tile	2
20	4	Standard Oil Co	Oil	
20	5	Pullman's Palace Car Co	Transportation	
May 3	1	Hired men	Services	56
7	2	M. M. Buck Manufacturing Co	Iron	
10	3	Mrs. B. Sutter	Rakes	
19	4	The Chicago and Alton R. R. Co	Transportation	1
June 4	1	Hired men	Services	58
9	2	L. M. Rumsey Manufacturing Co	Coal	1
23	3	Hired men	Services	9
		Total		7,22

REPORT OF MR. C. V. BRAINARD, ASSISTANT ENGINEER.

KAMPSVILLE, ILL., *June 30, 1898.*

MAJOR: I have the honor to submit the following report of operating and care of locks and dams, Illinois River, for the fiscal year ending June 30, 1898:

COMMERCE.

The commerce on that part of the Illinois River over which the United States exercises control is carried on by two regular packets, one belonging to the Eagle Packet Company, of St. Louis, Mo., and the other to the St. Louis, Hardin and Kampsville Packet Company, of Hardin, Ill. The former is a stern-wheel boat of 590.74 registered tons, being 204 feet long, 34 feet wide, with a draft light of 26 inches and capable of carrying 400 tons on a draft of 4 feet. This boat makes two round trips each week between St. Louis, Mo., and Peoria, Ill.

The latter boat has a registered tonnage of 337.3, is 153 feet long, 28 feet wide, with a draft light of 28 inches. This boat makes two round trips each week between St. Louis, Mo., and Montezuma, Ill., 60 miles above the mouth of the Illinois River.

In addition to these are 3 towboats ranging from 10 to 50 tons register, with 3 or 4 barges each. These boats draw from 2 feet to 30 inches, and can tow two of their barges at a trip carrying from 8,000 to 15,000 bushels of grain on a draft of 3 feet. These towboats do a greater part of the grain and lumber business. The lock reports do not show the entire business of the river, as a large quantity of freight originates and ends without passing through either lock.

Besides these, there is a fleet of towboats and barges used to take out the ice harvest of the upper river, which amounts annually to from 10,000 to 20,000 tons. This is principally taken out during the high water, the barges being loaded to 1,000 tons on about 8 feet draft. There is a statement herewith showing boats and tonnage passing Kampsville Lock and La Grange Lock, and one showing boats navigating the river.

LA GRANGE LOCK.

The lock gates were calked and painted; 10 of the straight chords were renewed, 2 in each leaf of the lower and 3 in each leaf of the upper gate. Repaired the valves in the head bay, putting in heavier holding-down bolts; new ties were put under the upper spar track; 2 clumps of piles of 7 piles each were driven above the river wall between the ice breaker and the end of the wall; 5 piles were driven above and 3 below the dam for anchors while working on the dam. One thousand four hundred and seventy cubic yards of mud was placed above the dam, filling to within 1 foot of the top of it. Two hundred and eighty-five cubic yards of this was taken from the lock chamber.

The 700 cubic yards of dirt, cast on the bank in June of the previous fiscal year, was graded into the low places about the grounds. The carpenter shop, storehouses, and blacksmith shop were moved on new foundations above high water and whitewashed. Fifty-two linear feet of cement walk was built, an 8-inch stone wall was built in the cistern to make it hold water. One hundred and forty tons of ice was put up. The machinery and boilers on dredge No. 1 and the pile driver laid up here were cleaned and painted; drift has been kept off the dam and grounds; 414 linear feet of 12-inch flashboards was put on the dam September 3 to 7 and removed at the close of navigation.

Navigation ceased November 22, 1897, and was resumed February 16, 1898. Boats began passing over the dam March 17 and continued to do so until June 23, except from May 10 to 19.

KAMPSVILLE LOCK.

The lock gates were painted, the iron work being painted twice; 400 cubic yards of sediment was removed from the lock chamber and from above the upper gates, about 300 cubic yards of which was cast on the bank over the land wall to be used for filling. Twenty-one piles in three clumps were driven for guide piles above the river wall and the same number below the land wall.

KAMPSVILLE DAM.

The slope on the upper side of the east abutment was filled with rock, it having settled somewhat. The corner between the revetment and dam at the east end of the dam was filled with 35 cubic yards of gravel and riprap. Flashboards 1 foot high were put on the dam August 23 to 25; these boards raised the water about 9 inches at La Grange Dam; they were removed the 1st of December, after the close of navigation. Seventy cubic yards of rock was boated across the river and piled near the abutment; 4,470 cubic yards of mud was filled in above the dam, filling it to the top for a distance of about 10 feet upstream.

Navigation ceased November 26, 1897, and was resumed February 13, 1898. Boats began passing over the dam March 23, and continued to do so until June 23, except from April 29 to May 19.

BUILDINGS AND GROUNDS.

House No. 1.—Papered all the rooms except the kitchen and two bed rooms, painted the walls of the kitchen, built 3 sets of outside steps, varnished the interior wood work.

House No. 2.—Painted exterior steps, surfaced and oiled kitchen floor and varnished interior wood work.

Office.—A small building formerly used for a bakeshop, was sided, lathed, and plastered, and fitted up for an office.

Watchhouse.—This building was painted inside and outside.

The storehouses and outbuildings were whitewashed.

About 500 cubic yards of grading was done, 300 cubic yards of which was leveling off that amount cast out of lock pit, being a part of the deposit in the lock since it has been in operation.

One thousand six hundred and fifty linear feet of sidewalk was built of material from the old dredge hulls. This was weighted down during the high water to keep it from floating off.

PLANT.

Ways.—Two new crabs were built for hauling out boats.

Dump scows.—Two new dump scows, numbers 7 and 8, were built.

Barges.—A small flat, 10 by 30 feet, was built for work about the dam.

CARE AND REPAIR OF PROPERTY AND PLANT.

Dredge No. 1.—One new spud was fitted with racks and shoe and put in dredge.

Dredge No. 2.—The engines were overhauled and put in order for next season's work, the machinery was painted, deck calked, and a pattern made for the dipper lip.

Dredge Apache.—Hauled the stern out on the ways and stopped a leak, put in new dipper handles, and calked the deck.

Barges.—Calked the seams of No. 2 above light water, and hauled Nos. 3 and 4 out on the ways and made in all seams under water.

Quarterboats.—No. 1: The cabin, hull, and roof were painted. No. 2: The cabin and hull were painted.

Office boat.—Hauled out and stopped the leaks, put on a new canvas roof, and painted the cabin inside and outside.

Scows.—Nos. 5 and 6 were hauled out and leaks stopped, hinges were remodeled, and 16 new doors made and hung.

Steam tender Marion.—All seams above light water were made in, engines lined up, machinery cleaned and painted, furnace rebuilt, and the boat painted.

Steam tender Pearl.—Machinery was overhauled, cleaned, and painted, and the furnace repaired. The engines were lined up.

Steam tender Fox.—All seams above light water were made in, the engines lined up, and the machinery was painted.

Very respectfully, your obedient servant,

C. V. BRAINARD,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers.

Tonnage passing Lagrange Lock.

	Fiscal year ending June 30—								
	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Steamboats...number..	142	280	265	291	296	374	340	416	420
Barges.....do....	68	147	168	176	213	251	164	224	235
Steamboats ..tonnage..	41,915	63,967	68,236	80,131	59,730	60,814	79,495	91,550	90,780
Barges.....do....	12,386	45,711	79,211	162,118	91,361	76,530	49,802	76,091	80,925
Ice.....tons..	(a)	20,575	39,400	46,600	31,900	11,950	11,150	19,425	11,975
Wheat .....bushels..	5,082	9,800	14,536	12,700	6,750	22,017	30,142	21,477	6,850
Corn ....do....	(a)	18,176	33,800	29,691	45,900	87,563	67,179	161,767	187,500
General Merchandise, tons.....	(a)	(a)	1,651	4,675	3,734	1,976	6,455	4,508	3,134
Passengers...number..	(a)	(a)	1,334	2,382	2,179	4,682	6,391	4,774	10,300
Coal .....tons..	100	650	729	225	1,087	640	80	320	395
Stock.....head..	(a)	(a)	219	298	2,307	1,323	1,925	1,657	2,516
Wood.....cords..	.....	70	250	250	60	28	.....	35	90
Logs.....feet B. M..	.....	45,000	.....	181,000	200,000	.....	.....	70,000	33,500
Lumber.....do....	.....	.....	10,000	15,000	50,000	.....	10,000	70,000	10,000
Apples.....barrels..	.....	.....	.....	.....	.....	.....	9,670	158	2,352

a No record kept.

Tonnage passing Kampsville Lock.

	Fiscal year ending June 30—				
	1894.	1895.	1896.	1897.	1898.
Steamboats.....number..	177	440	436	320	328
Barges.....do....	120	192	156	106	100
Steamboats.....tonnage..	57,149	99,315	111,382	107,855	124,253
Barges.....do....	51,295	81,597	54,304	66,769	66,718
Ice.....tons..	31,900	11,950	10,950	19,425	11,925
Wheat.....bushels..	63,600	178,025	158,795	130,081	39,719
Corn.....do....	86,267	164,000	178,188	72,047	63,367
Other grain.....do....	.....	1,284	2,567	1,873	5,426
Apples.....barrels..	.....	2,359	6,396	1,231	5,618
General merchandise.....tons..	4,692	3,454	8,169	7,899	5,960
Passengers.....number..	1,197	5,017	7,049	4,796	5,670
Stock.....head..	3,760	8,735	12,358	14,603	14,472
Logs.....feet B. M..	.....	.....	.....	30,000	85,000

List of boats navigating the Illinois River.

Name.	Registered tonnage.	Name.	Registered tonnage.
Charlotte Boeckeler	143	New Idlewild	692
Cherokee	631	D. H. Pike	465
Bald Eagle	591	Jack Frost	350
Josie	233	R. C. Gunter	337
Carrier	245	Polar Wave	150
Elk	111	U. S. Lily	206
G. M. Sivley	99	Mary Stewart	91
Joliet	76	Ruth	61
Romeo	61	Josie Sivley	47
H. W. Longfellow	47	Hebe	36
Leo	36	Edith K	23
Lotus	22	Wm. McGee	17
Waikiki	17	R. G. Schmoldt	14
Enterprise	15	La Tosca	12
Belle of Ottawa	11	Mabel	8
Peoria	5	City of Pekin	5

J J 7.

CONSTRUCTION OF ILLINOIS AND MISSISSIPPI CANAL

The object of this improvement is to furnish a navigable waterway from Lake Michigan at or near Chicago, Ill., to the Mississippi River at the mouth of Rock River, near Rock Island, Ill., in connection with the Upper Illinois River and the proposed enlarged waterway along the present line of the Illinois and Michigan Canal.

Various surveys of different routes from the great bend of the Illinois, near Hennepin, Ill., to the Mississippi River, at or above the mouth of Rock River, have been made, viz: In 1871 (Report Chief of Engineers, 1871, p. 303), in 1882 (Report Chief of Engineers, 1883, p. 1757), and in 1885 (Report Chief of Engineers, 1886, p. 1707).

There was also a report upon the canal by a board of engineers in 1887 under the provisions of the river and harbor act of August, 1886 (Report Chief of Engineers, 1887, p. 2145).

After much discussion the present or Rock Island route was adopted.

Detailed plans and estimates, based upon preliminary surveys and under the river and harbor act of August 11, 1888, were prepared in this office and submitted to Congress, June 21, 1890, the report of which plans and estimates was published as House Ex. Doc. No. 316, Fifty-first Congress, first session. This report was the basis of subsequent appropriations.

The plans submitted in 1890 were subsequently modified (Reports Chief of Engineers, 1891, 1892, 1896, and in papers herewith) and con-

template the construction of a canal at least 80 feet wide at the water surface, 7 feet deep, with locks 170 feet long between quoins, 35 feet wide, admitting barges carrying 600 short tons of freight, if we allow 240 short tons for weight of vessels, and 140 feet length, 34 feet beam, and 6 feet draft of vessel that may easily navigate the canal.

The canal to begin at the Great Bend of the Illinois River; thence via the valleys of Bureau, Pond, and Cowcatcher creeks to the summit level near the eighteenth mile, ascending 196 feet through 21 locks, with lifts varying from 7 to 11 feet each; thence to the Feeder Junction near the twenty-eighth mile; thence to Rock River, just above the mouth of Green River; thence down Rock River to its mouth. The length of the canal is about 75 miles, having been shortened about 2 miles by the adoption of the Green River route instead of the Penney Slough route. The descent from the summit level to the low-water level of the Mississippi River is 93 feet, effected by 10 lift locks from 6 to 14 feet lift, with 1 guard lock. The number of lift locks has been reduced from 37 to 31, and the summit level has been cut down 9 feet in the changes since the 1890 report by subsequent surveys, and the length of the main line of the canal has been reduced from 77 to 75 miles.

The feeder as now located is 29 miles in length, instead of 34¾ miles as proposed in 1890, and 37½ miles as proposed in 1871 and in 1883.

The entire line of the canal and feeder has now been definitely located by authority of the Secretary of War, as required by river and harbor act of August 11, 1888, and subsequent act of Congress. The estimated cost of the canal has not been increased by the changes in location, but the lockage has been reduced by 18 feet, the length of the canal and feeder by from 7 to 9 miles, the number of locks by 6, and the resulting time of passage between the Illinois and Mississippi rivers due to these changes about three hours, or about 10 per cent, and the probable cost of maintenance and operation has been correspondingly reduced.

CONDITION OF THE WORK JUNE 30, 1898.

Work began under the conditions imposed by the river and harbor act of September 19, 1890, upon the Rock River end of the canal in 1892, by the construction of a canal around the lower rapids of Rock River, 4½ miles long, with 3 locks, 3 swing bridges, 2 dams, 3 lock houses, 7 sluiceways, and 1 arch culvert, which canal was opened to navigation April 17, 1895, and has since that date been in successful operation.

Further prosecution of work on the Rock River section has been prevented by the Moline wagon bridge across Rock River, a short distance above the head of the canal, which prevents the passage of all craft requiring 11 feet or more head room. Procedings were instituted in the United States district court to compel the removal of this obstruction, the authority of the Secretary of War in the matter having been denied by the city of Moline. The sundry civil act of July 1, 1898, allots $25,000 of the amount appropriated for the construction of the canal to be expended in the construction of a high bridge in lieu of this objectionable structure. No estimates of the cost of such high bridge had been made, and Rock River had been declared, by decree of the U. S. circuit court for the northern district of Illinois on the finding of a jury as to the fact, to be a navigable river of the United States up to and beyond Sterling, Ill., prior to this appropriation for this bridge.

All appropriations made subsequent to the act of September 19, 1890,

have been expended in locating the canal, acquiring the right of way, and in constructing the eastern section, beginning at the Illinois River and proceeding westward.

At the date of this report 8 miles of the canal trunk on the eastern section, except the entrance to Lock 1 from the Illinois River, have been completed, and 7 miles paved along the water line with stone. The earthwork of the second 8 miles is nearing completion, and of the third 8 miles is in progress. The foundations, masonry, and pipes of all culverts on the first 16 miles have been completed, also the masonry of 10 locks, 1 aqueduct, and abutments of 6 highway bridges have been constructed. The foundations of Locks 11, 12, 13, 14, 19, and 21 are completed, ready for the masonry, and of Locks 15, 16, 17, 18, and 20 nearly completed. The masonry of Lock 11 is near completion (completed July 7, 1898) and the forms ready for deposit of concrete at Lock 12, and begun at Lock 13.

The superstructure of 1 highway bridge is completed. The metal work of three additional highway bridges placed on their abutments, and of 2 highway bridges delivered at the sites. The foundation of Aqueduct No. 2 is under way. The right of way of the eastern section has been secured and paid for up to the end of the twenty-fourth mile. There remains 7 pieces to be condemned between end of mile 24 and the feeder junction at mile 27.8. The right of way for the entire feeder line, except one piece at the feeder junction, also for more than one-third of the western section and a few pieces of the overflow lands, have been condemned and awards made, but the payments of the awards have not been made. These lands will probably be in possession of the United States by September 1, allowing the feeder to be put under contract under the appropriation made July 1, 1898.

PROGRESS OF THE WORK DURING FISCAL YEAR ENDING JUNE 30, 1898.

I.—CONTRACT WORK.

(*a*) Under contract dated June 19, 1897, with Katz, Crandall & Callahan, of Omaha, Nebr., for the construction of earthwork, creek diversions, and slope wall protections from miles 9 to 16, inclusive, the following work has been done: 1,214,455 cubic yards earth excavation, 110,722 cubic yards hardpan excavation, requiring blasting for removal, and 8,541 square yards paving of slope walls, completing the earthwork of miles 9, 10, 11, 12, 13, 14; mile 15, 98 per cent; mile 16, 90 per cent. The contract will probably be completed September 1 and closed.

(*b*) Under contract with Cogan & Pound, of Chicago, Ill., dated June 19, 1897, for constructing lock pits and foundations for 11 locks and 2 aqueducts, there have been completed foundations of Locks 8, 9, 10, 11, 12, 13, and 14; partly completed, Locks 15, 16, 17, and 18, and foundations of piers, etc., of Aqueduct No. 2. The foundations of Aqueduct No. 3 have not been begun. The detailed amounts of work are given in the report of Assistant James C. Long, hereto appended.

(*c*) Under contract with McArthur Bros., of Chicago, Ill., dated June 19, 1897, for the construction of 2 concrete arch culverts and 6 cast-iron pipe culverts, all the work has been done and the contract closed.

(*d*) Under contract with John J. McCaughey, Summit, Ill., dated October 6, 1897, for construction of canal trunk, miles 17 and 18, 69,410 cubic yards earthwork has been done; mile 17, 4 per cent done; mile 18, 66 per cent done.

(*e*) Under contract with the Globe Construction Company, of Cincinnati, Ohio, dated October 6, 1897, for construction of canal trunk, miles 19 to 23, inclusive, 66,279 cubic yards earthwork and 18,281 cubic yards hardpan, requiring blasting for removal, have been done; all on mile 19. The progress has been very unsatisfactory under this contract.

(*f*) Under contract with R. C. Cushing & Co., Chicago, Ill., dated October 6, 1897, for earthwork on mile 24, no work has been done during the fiscal year. The mile is marshy and the contractors have been permitted to delay work until September, 1898. Their contract expires September 30, 1899.

(*g*) Under contract with the Toledo Bridge Company, Toledo, Ohio, dated January 4, 1898, for the construction of 5 steel highway bridges, the metal work of all the bridges has been delivered, and of 3 of them placed upon the abutments. The riveting and floors of 3 bridges and the erection of 2 remains to be done.

(*h*) Under contract with H. A. Boedker & Co., Chicago, Ill., dated October 6, 1897, for the excavation of lock pits and construction of foundations of three locks, the work for Locks 19 and 21 has been completed; the foundation of Lock 20 is nearing completion.

The contracts dated October 6, 1897, for canal work were entered into so late in the season that no work could be done under them in the calendar year 1897, and the calendar year 1898 up to June, 1898, has been so remarkably rainy and wet that it has been impracticable along the marshy summit level sections of the canal for the contractors to do effective work. In making the contracts the conditions were kept in mind and two years were allowed for the work, whereas for the June contracts one year only was allowed. With a good season it is hoped that rapid progress will be made in the calendar year 1898 on contract as well as hired-labor work.

II.—HIRED-LABOR WORK.

Under approved projects the masonry abutments and approaches of bridges, the masonry of locks, the lining of the canal with stone along the water line, the filling in rear of lock walls, and various small detached pieces of work included under the heading finishing and cleaning-up work has been done by hired labor. This includes the most expensive, tedious, and most difficult to estimate, work of construction that can not well be put out to contract with safety. All survey work and that relating to the acquisition of the right of way is necessarily done by hired labor, and the purchase of material under the laws of the United States and regulations governing purchases.

(*a*) *Eastern section.*—The detailed statement of quantities is given in the report of Asst. Engineer J. C. Long, hereto attached. Concrete masonry, Locks 8, 9, and 10, were completed during the year, and of Lock 11 nearly completed. Forms were erected for these locks and also for Lock 12. The abutments of highway bridges 1, 2, 3, 4, and 10 were completed, and the earthwork approaches of these bridges nearly completed. The earth filling behind Locks 1, 2, 3, 4, 5, 6, and 7, and the splay walls of these locks, were completed. The stone paving along the water line for a width of 6 feet, measured on the inner slope, was placed on the first 8 miles of the canal, except about 1 mile where the banks have been prepared for the paving and the stone distributed, but not yet laid up. A telephone line 24 miles long with 9 instruments in circuit has been constructed. A gravel quarry was stripped and all gravel and broken stone and other supplies for the work distributed. Material

the masonry of the canal except dry-stone revetments, head walls
e culverts, and retaining walls of bridge approaches, which are
rubble, is of artificial stone or concrete. Great care has been
to secure good results, and the work has been so systematized by
ience as to enable the officer in charge to formulate definite
ctions. The objection to the use of artificial stone is the unreliа-
of Portland cement of the cheaper grades, and the requirements
laws and regulations regarding purchases. The testing requires
ınd skill, neither of which is always available upon an actively
:uted work, and unless undoubted evidence of inferiority is forth-
g the responsible bidder offering the cheapest article will get the
ıct. The result in such cases is likely to be disastrous. On this
no proposals have been asked from manufacturers other than
whose products have been tested in this office and moreover have
permanency in this climate, but we have not succeeded in all cases
ing satisfactory cement. The lowest-bidder clause governs and the
ıre of a very large pay roll, the need of material, and want of time
)per testing prior to use have in several instances resulted in the
g of cement, even of high repute, but low price, that would prop-
ave been rejected. So far, however, no ill consequences have
ed the mistakes of this kind, but a feeling of insecurity and uncer-
must attach to this class of work in the mind of engineers respon-
or it, until the manufacturers find it to their interest not to ship
cement or such that will not rigidly fulfill the requirements of
ecifications to their contracts. Deliberate testing is often imprac-
on small works on account of cost, and in large, active works on
ıt of lack of time from pressure for material and cost of storage
or a large supply well in advance of its use. The tests required
office are given in the previous annual reports. The following
ctions relate to the work of construction of concrete masonry of
:ks on the canal:

ORGANIZATION.

time, and when completed, to see that it conforms to the drawings and to the instructions given in regard to nailing on the facing plank. The inspector shall be held responsible for accuracy in laying out and in dimensions.

4. The concrete masonry of locks shall be constructed by hired labor, and when the concrete work is commenced on any section of a lock or other work it must be prosecuted day and night without intermission to completion of said section.

5. The working forces shall be divided into three shifts of eight hours each, change of shift being made at such hours as may be designated by the assistant engineer.

6. Each shift shall consist of one overseer in general charge, one suboverseer or master laborer in charge of the ramming gang, and the foremen, engine drivers, track layers, carpenters, and laborers necessary for the skillful and economical execution of the work.

7. Provision shall be made for the continuous inspection of concrete work in progress, and to this end a junior engineer or inspector shall be detailed with each working shift, whose duty it shall be to remain constantly on the work during his shift, and to see that all operations are carried on in an accurate, careful, and conscientious manner, according to the true intent and meaning of the specifications. He shall be authorized, in the absence of his superiors, to give orders necessary for the proper execution of the work, and will be held accountable for any bad work. The junior inspector shall be under the immediate orders of the senior inspector, and shall report to him for instructions, and inform him periodically of all faulty work or neglect on the part of any member of the working forces.

8. The overseer of each shift shall have immediate direction of the working gangs and must maintain a proper organization and discipline, so that the work may proceed without delay and every man worked to his full capacity. He shall keep himself well informed as to men and material needed, and shall make timely requisition on the senior inspector for the same. At the close of each day's work he shall submit to the senior inspector or other authorized person a time report, giving the names or numbers, duties, and time of all the men employed during the shift.

9. The overseer of each shift shall be required to obey promptly and cheerfully all orders given by the inspector on duty in relation to the execution of the work, and shall require his foremen and other assistants to do likewise.

10. The suboverseer or master laborer in charge of the ramming gang occupies a post of importance and should possess special qualifications. His duties are to secure a uniformly thorough ramming of the whole mass of concrete and an unbroken face to the lock wall. One or more careful men should be taught to place and ram the facing. These same men shall always be put at this work when possible.

PROPORTIONS AND MIXING OF CONCRETE.

11. Proportions and ingredients are measured by volume, and the number of cubic feet given below represent the quantities to be used for each charge of concrete put into the mixer.

Portland cement concrete shall in general consist of:

Portland cement, 1 part = 5 cubic feet = 5 sacks.
Gravel, 4 parts = 20 cubic feet.
Broken stone, 4 parts = 20 cubic feet.

Natural cement concrete shall consist of:

Natural cement, 2 parts = 8 cubic feet = 4 sacks.
Gravel, 5 parts = 20 cubic feet.
Broken stone, 5 parts = 20 cubic feet.

Facing material shall consist of, by volume:

1. Portland cement.
3. Torpedo sand passing No. 5 sieve.

12. The piles of gravel and broken stone shall be kept thoroughly sprinkled with water to clean surface of dust and to prevent absorption by the dry stone of the water used in mixing the concrete.

13. When delivered in bags each bag of cement shall be emptied directly into the charging box, as the division of a barrel of cement into several bags diminishes the chances of injurious effect of a defective barrel, and hence the usual requirements of drawing charges from a mixture of five or more barrels may be dispensed with. When delivered in barrels this latter requirement will be observed.

14. All bags and sacks shall be carefully preserved for return to the dealers furnishing cement, in order to secure to the United States the rebate thereon, to be deducted from subsequent bills for cement.

15. The proper measures of ingredients shall be emptied into the charging box in the following order: First, gravel; second, cement; third, broken stone; fourth, water.

16. Enough water shall be added to make the concrete cohere after a thorough mixing. A greater degree of plasticity than that possessed by damp sand is required,

and the object is to have the consistency such that a thorough ramming will bring water to the surface. The mass of concrete should not quake on ramming; incipient quaking marks the limit, and any excess of water in one charge may be corrected by making the next charge a little dryer. The proper amount of water can be determined only by experience, and must be varied from time to time to suit the conditions of the weather and the ingredients. It is very important that Portland cement shall have sufficient water for its complete hydration. Natural cement requires less water for hydration than Portland.

17. The contents of the charging box shall be dumped immediately into the cubical mixer, which shall be revolved for not less than two minutes at a rate not exceeding nine revolutions per minute. The product is improved by longer mixing, and all the time less than period required for initial set available between deliveries required at the forms should be utilized for extra turns to the mixer. The facing material shall be mixed by hand, and a very small gang will be able to keep the forms supplied, as for a facing of a uniform thickness of two inches about 70 cubic yards only will be required for a lock, or about 3½ cubic yards to each section. A close watch must be kept of the quantity used, and the above limit must not be exceeded.

DEPOSITING AND RAMMING CONCRETE.

18. Each lock wall shall be built in sections, averaging about 20 feet in length, making 10 sections to each wall. The planes of division between sections shall be at right angles to the axis of the lock, and are indicated on drawings furnished from this office.

19. Each section shall be a monolithic mass of concrete built continuously from the bottom to completion without horizontal joints. The sections shall be filled with horizontal layers about six inches thick, each layer to be deposited before the "initial" set of the previously deposited layer.

20. The vertical planes of division between sections shall be made by transverse bulkheads built in the forms and at each bulkhead a dovetail or recess shall be made for the interlocking of adjacent sections, the dovetails reaching from foundation to one foot below the coping of the sections.

21. Alternate sections shall be built first, then the bulkheads shall be removed and the remaining sections filled with concrete.

22. Before beginning a section its foundation shall be swept clean with wire brooms and covered with a wet layer one inch thick of 1 to 1 cement mortar to make a close joint between the wall and the foundation.

23. The walls of the wooden forms shall be kept well wet during the progress of the concrete work to prevent their absorption of water from the newly placed concretes.

24. The lowest step or thickest part of the lock walls shall consist of not less than 2 feet of Portland cement concrete next to the face of the wall and a backing of natural cement concrete. All other walls or parts of walls shall be of Portland cement concrete.

25. The exposed faces and copings of all walls shall consist of Portland cement and torpedo sand 1 to 3. The thickness of facings shall not exceed 1½ inches, nor be less than three-fourths inch.

26. The facing and backing must go on simultaneously in the same horizontal layers. In order to gauge the thickness of the facing accurately, a light board or diaphragm of thin metal with convenient handles shall be set on edge parallel to and 1½ inches from the front wall of the forms. The facing material shall be deposited in the space between this board and the form. The concrete of the backing shall then be deposited and spread against the back of this board, which may then be withdrawn and the whole mass thoroughly rammed so as to bond the facing and backing by destroying the surface of demarcation between them, but no stone must be forced nearer to the front wall of the form than three-fourths inch. No attempt shall be made to secure a definite surface between the Portland and natural cement concrete in the lowest step of the lock walls, but they shall be thoroughly bonded, blended, and interlocked, one into the other, by long lap or splice joints in every layer deposited.

27. When the top surface of the coping is reached it shall be finished after ramming by cutting off the excess with a straight edge and rubbed smooth and hard with a float by skilled sidewalk finishers. The wet finishing coat shall be of 2 to 3 mortar with torpedo sand, and shall be as thin as possible without exposing the stone or gravel of the concrete below, 1 inch is sufficient thickness. The coping of lock walls shall be slightly crowned in the center.

28. The facing and coping shall show a smooth dense surface without pits or irregularities. This is most likely to be secured by thorough and systematic ramming.

29. Concrete shall not be laid in water nor exposed to the action of water until thoroughly set. Concrete or mortar shall not be made when the temperature is

lower than 35° Fah. in the shade, nor when rain is falling on it. All concrete work shall cease November 20, and not be resumed before April 1. Forms and molds must be left in position for not less than four days after concrete is deposited. Freshly deposited concrete shall be protected from the direct rays of the sun and wind by boards or tarpaulins, and as soon as a section of wall is completed the exposed coping must be covered with a thick layer of wet sand and the whole mass of wall must be kept sprinkled until the concrete is thoroughly set.

DELIVERY OF MATERIAL.

30. Stone and gravel shall be delivered in as compact piles as possible, so as to reduce the average length of haul to the concrete mixer.

31. Torpedo sand shall be screened directly into cars at the gravel pit, and this work dispensed with at the lock site. The pebbles resulting from this screening shall be regarded in mixing as crushed stone.

32. Cement can probably be delivered as required for use. No large amount should be in temporary shelters, nor exposed to danger of injury by rain or damp weather.

RECORDS AND REPORTS.

33. An accurate report of the time and duties of all men employed on the shift should be submitted daily by the overseer of each shift as soon after the close of work as possible. This report shall be in writing, signed by the overseer, and shall be handed to the inspector or to the clerk or timekeeper designated by him.

34. From time to time, once every day if practicable, at irregular times, the clerk or timekeeper shall visit the work in person and note the men actually employed, and such record shall be used as a check on the overseer's time report.

35. An accurate record of all material put into the work or used in connection therewith shall be kept by the receiver of material, under the direction of the assistant engineer, and the inspector in charge of construction shall afford every facility for obtaining the information essential to such record.

36. The inspector in charge of construction shall upon completion of the masonry of each lock prepare a report of the cost of the work, giving the quantities of each class of material used and the labor account of each class of operations (as delivering material, erecting and removing forming, mixing and depositing concrete, etc.).

37. To aid in fixing responsibility for defective work due to carelessness in placing concrete, it is ordered that an "inspection sheet" be prepared for each lock, on which shall be shown graphically the exact location and amount of work done by each shift, the hours and date of such work, and the names of the junior inspector, overseer, and head of ramming gang on duty with such shift. The employees named will be held strictly responsible for the quality of the work, and inefficiency or carelessness will not be tolerated.

38. The data for the inspection sheet shall be furnished daily by the junior inspector with each shift to the inspector in charge of construction, who shall satisfy himself that the data are correct.

39. The inspector in charge of construction shall sign the inspection sheet, certifying to its correctness, and shall submit the same to the assistant engineer, with full information in regard to the execution of the work and the efficiency of his subordinates.

40. The assistant engineer, in submitting the inspection sheet to the officer in charge, will report as to the quality of the concrete work and the character of the inspection.

41. Competent inspection service must be maintained, and inspectors must be thoroughly trained in their duties. Inspectors exhibiting special qualifications for concrete work shall be retained on such work throughout the season.

42. The duties of the inspectors must not be confounded with those of the overseers. The overseer is employed to do the work, the inspector to see that the work is done properly; the overseer should organize and govern the working parties and designate their duties and the order of their detailed operations, the inspector is the judge of the methods employed, and a director of the work so far as to require the best methods and material necessary to the attainment of specified results.

WESTERN SECTION.

The work on this section has been confined to operations for securing right of way and to office work relating to detailed plans and estimates of the work of construction of the section. More than one-third of the right of way has been condemned and awards made, but the amounts awarded have not been paid.

FEEDER LINE.

During the year all lands required for right of way for the feeder, except one piece, have been condemned and awards made. They will be paid for as rapidly as practicable. All necessary work of preparing estimates, etc., for putting the feeder under contract has been done.

The work on feeder and western section has been in charge of Mr. L. L. Wheeler, assistant engineer, whose report in detail, accompanied by two index maps showing the present status of the right-of-way matter, with a full description of the methods employed in securing title to lands as far as relate to the duties of this office, is hereto appended.

PROPOSED APPLICATION OF FUNDS NOW ON HAND AND THOSE ASKED FOR FOR FISCAL YEAR ENDING JUNE 30, 1900.

It is proposed to apply these funds to completing the work now under contract; to continuing by hired labor the construction of locks, aqueducts, piers, and abutments of bridges; lining the canal trunk with stone, filling behind locks, and other finishing work now in progress; to the payment of awards already made for right of way; to the construction of earthwork, etc., under contract, of the feeder, and generally to push toward completion the construction of this canal.

A series of photographic views of characteristic work on the eastern section accompanies this report.

Appropriations.

July 1, 1890, balance unexpended from previous appropriations	$786.46
Act of—	
September 19, 1890	500,000.00
July 13, 1892	500,000.00
August 17, 1894	190,000.00
June 3, 1896	45,000.00
Sundry civil act June 4, 1897	875,000.00
Sundry civil act July 1, 1898	1,427,740.00
Total	3,538,526.46
Expended to June 30, 1898	1,748,905.13
Balance unexpended July 1, 1898	1,789,621.33

Money statement.

July 1, 1897, balance unexpected		$906,898.91
Amount appropriated by sundry civil act approved July 1, 1898		1,427,740.00
		2,334,638.91
June 30, 1898, amount expended during fiscal year		545,017.58
July 1, 1898, balance unexpended		1,789,621.33
July 1, 1898, outstanding liabilities	$93,214.90	
July 1, 1898, amount covered by uncompleted contracts	244,785.61	
		338,000.51
July 1, 1898, balance available		1,451,620.82
Amount (estimated) required for completion of existing project		*3,433,490.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		1,427,740.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

*$25,000 appropriated for constructing bridge across Rock River, at Moline, Ill. (sundry civil act July 1, 1897), added to amount required for completion.

ILLINOIS AND MISSISSIPPI CANAL—WESTERN SECTION.

Around lower rapids of Rock River.—Total cost.

[Completed and in operation.]

Surveys	$22,938.92
Right of way	26,851.14
Canal trunk:	
Mile 1	24,154.91
Mile 2	18,985.64
Mile 3	18,680.01
Miles 4 and 5	126,716.52
Lock No. 37	89,542.31
Lock No. 36	39,532.19
Guard lock	72,696.97
Dams	35,086.13
Bridges	39,437.89
Property (to be charged entire canal, when completed)	32,607.30
Total	547,229.93

Rock River division.—Annual statement, fiscal year 1898.

Dredging Rock River	$470.21

Feeder junction to Rock River.—Annual statement, fiscal year 1898.

Surveys	$9,371.37
Right of way	1,355.65
Total	10,727.02

Feeder junction to Rock River.—Cost to close of fiscal year 1898.

	At close of 1897.	Fiscal year 1898.	Total.
Surveys	$8,801.75	$9,371.37	$18,173.12
Right of way	.....	1,355.65	1,355.65
Total	8,801.75	10,727.02	19,528.77

Feeder line.—Annual statement, fiscal year 1898.

Surveys	$1,741.87
Right of way	399.82
Property	124.47
Total	2,266.16

Feeder line.—Cost to close of fiscal year 1898.

	At close of 1897.	Fiscal year 1898.	Deteriora tion of property.	Total.
Surveys	$25,512.94	$1,741.87	$25.80	$27,280.61
Right of way	2,846.47	399.82	.....	3,246.29
Property	4.56	124.47	.....	103.23
Total	28,363.97	2,266.16	25.80	30,630.13

Eastern section.—Annual statement, fiscal year 1898.

Surveys	$292.16
Right of way	43,592.69
Canal trunk:	
Mile 1	8,776.38
Mile 2	7,458.01
Mile 3	6,602.29
Mile 4	9,222.51
Mile 5	8,004.08
Mile 6	4,529.67
Mile 7	4,482.41
Mile 8	8,090.23
Mile 9	15,287.02
Mile 10	15,016.68
Mile 11	20,257.71
Mile 12	9,739.34
Mile 13	16,002.20
Mile 14	9,033.03
Mile 15	40,875.28
Mile 16	27,989.17
Mile 17	752.51
Mile 18	4,235.21
Mile 19	8,997.88
Mile 20	468.82
Mile 21	353.92
Mile 22	322.39
Mile 23	351.88
Mile 24	451.91
Locks:	
No. 1	597.59
No. 2	1,313.04
No. 3	1,849.40
No. 4	723.16
No. 6	692.26
No. 7	1,510.83
No. 8	22,464.35
No. 9	9,064.74
No. 10	11,287.00
No. 11	11,091.07
No. 12	6,550.16
No. 13	6,456.56
No. 14	4,381.24
No. 15	1,483.29
No. 16	1,820.49
No. 17	894.56
No. 18	4,669.41
No. 19	10,362.06
No. 20	1,831.33
No. 21	8,963.44
Arch culverts:	
No. 1	$175.41
No. 2	420.38
No. 3	233.56
No. 4	406.85
No. 5	17.00
No. 6	6,899.89
No. 7	8,530.65
Pipe culverts:	
No. 5	2,981.54
No. 7	2,024.07
No. 8	2,349.44
No. 9	1,338.73
No. 10	1,700.61
No. 11	1,359.19
Aqueduct No. 2	136.93
Highway bridges:	
Mile 2	1,971.12
Mile 5, No. 2	1,663.96
Mile 7	2,501.77
Mile 8	2,381.39
Mile 13	21.60
Mile 15	340.93
Mile 16	5,025.50
New highway, mile 16	4,898.66
Houses:	
At Lock No. 3	1,854.51
At Lock No. 6	1,107.40
At Lock No. 11	1,555.30
At Lock No. 13	354.92
At Lock No. 19	1,689.70
On mile 23	211.43
On mile 24	170.95
Gravel pit	9,722.48
Lock forming	4,566.62
Telephone line (unfinished)	397.92
General construction	29,308.75
Superintendence and office	24,338.60
Care and repair of property and plant	6,217.87
Property	9,199.11
Material (stock on hand)	30,408.21
Total	547,674.51
Less material on hand June 30, 1897	16,120.32
Total for fiscal year 1898	531,554.19

Total cost to close of fiscal year 1898.

	At close of 1897.	Fiscal year 1898.	Deterioration of property and plant.	Equitable part of general construction.	Equitable part of superintendence and office.	Equitable part of care and repair.	Total.
Surveys	$29,644.58	$292.16					$29,936.74
Right of way	67,807.58	43,592.69					111,400.27
Canal trunk:							
Mile 1	14,867.62	8,776.38	$99.21	$322.31	$548.22	$140.06	24,753.80
Mile 2	14,519.01	7,458.01	84.31	273.89	465.86	119.02	22,920.10
Mile 3	14,160.67	6,602.29	74.63	242.46	412.41	105.36	21,597.82
Mile 4	34,490.56	9,222.51	104.25	338.69	576.08	147.17	44,879.26
Mile 5	22,447.35	8,004.08	90.48	293.94	499.97	127.73	31,464.05
Mile 6	10,822.66	4,529.67	51.21	166.35	282.95	72.39	15,925.13
Mile 7	12,606.88	4,482.41	50.67	164.61	279.99	71.53	17,656.09
Mile 8	10,452.69	8,090.23	91.45	297.11	505.35	129.11	19,565.94
Mile 9	461.19	15,287.02	172.81	561.40	954.90	243.95	17,681.27
Mile 10	455.74	15,016.68	169.75	551.48	938.01	239.64	17,371.30

Total cost to close of fiscal year 1898—Continued.

	At close of 1897.	Fiscal year 1898.	Deterioration of property and plant.	Equitable part of general construction.	Equitable part of superintendence and office.	Equitable part of care and repair.	Tot
Canal trunk—Cont'd.							
Mile 11	$446.81	$20,257.71	$228.99	$743.95	$1,265.39	$323.27	$23,2
Mile 12	446.27	9,739.34	110.10	357.68	608.36	155.42	11,4
Mile 13	219.81	16,002.20	180.89	567.67	999.57	255.36	18,2
Mile 14	203.00	9,033.03	102.11	331.73	564.24	144.15	10,3
Mile 15	215.01	40,875.28	462.06	1,501.11	2,553.26	652.29	46,2
Mile 16	233.91	27,989.17	316.39	1,027.88	1,748.34	446.65	31,7
Mile 17	.....	752.51	8.51	27.64	47.01	12.01	8
Mile 18	.....	4,235.21	47.88	155.53	264.55	67.59	4,7
Mile 19	.....	8,997.88	101.71	330.44	562.05	143.59	10,1
Mile 20	.....	468.82	5.30	17.22	29.28	7.48	5
Mile 21	.....	353.92	4.00	13.00	22.11	5.65	3
Mile 22	.....	322.39	3.65	11.85	20.14	5.15	3
Mile 23	.....	351.88	3.98	12.92	21.98	5.62	3
Mile 24	.....	451.91	5.11	16.60	28.23	7.21	5
Locks:							
No. 1	37,474.15	597.59	6.76	21.95	37.33	9.54	38,1
No. 2	39,290.13	1,313.04	14.84	48.22	82.02	20.96	40,7
No. 3	35,355.98	1,849.40	20.91	67.92	115.52	29.51	37,4
No. 4	35,882.05	723.16	8.18	26.56	45.18	11.54	36,6
No. 5	37,800.99	.....	.....	.....	.....	.....	37,8
No. 6	39,093.50	692.26	7.83	25.43	43.25	11.05	39,8
No. 7	33,024.97	1,510.83	17.08	55.48	94.37	24.11	34,7
No. 8	.....	22,464.35	253.94	824.98	1,403.23	358.49	25,3
No. 9	.....	9,064.74	102.47	332.90	566.22	144.66	10,2
No. 10	.....	11,287.00	127.59	414.40	705.04	180.12	12,7
No. 11	.....	11,091.07	125.37	407.31	692.80	176.99	12,4
No. 12	.....	6,550.16	74.04	240.56	409.16	104.53	7,3
No. 13	.....	6,456.56	72.99	237.11	403.31	103.04	7,2
No. 14	.....	4,381.24	49.53	160.91	278.67	69.92	4,9
No. 15	.....	1,483.29	16.77	54.47	92.65	23.67	1,6
No. 16	.....	1,820.49	20.58	66.86	113.72	29.05	2,0
No. 17	.....	894.56	10.11	32.85	55.88	14.28	1,0
No. 18	.....	4,669.41	52.78	171.48	291.67	74.52	5,2
No. 19	.....	10,362.06	117.13	380.54	647.26	165.36	11,6
No. 20	.....	1,831.33	20.70	67.25	114.39	29.23	2,0
No. 21	.....	8,963.44	101.32	329.19	559.90	143.04	10,0
Pipe culverts:							
No. 1	3,295.57	.....	.....	.....	.....	.....	3,2
No. 2	201.86	.....	.....	.....	.....	.....	2
No. 3	7,245.74	.....	.....	.....	.....	.....	7,2
No. 4	6,062.58	.....	.....	.....	.....	.....	6,0
No. 5	.....	2,981.54	33.71	109.49	186.24	47.58	3,3
No. 7	.....	2,024.07	22.88	74.33	126.44	32.30	2,2
No. 8	.....	2,349.44	26.56	86.29	146.76	37.50	2,6
No. 9	.....	1,338.73	15.13	49.17	83.62	21.36	1,5
No. 10	.....	1,700.61	19.22	62.45	106.23	27.14	1,9
No. 11	.....	1,359.19	15.37	49.92	84.90	21.69	1,5
Arch culverts:							
No. 1	8,903.33	175.41	1.98	6.44	10.96	2.80	9,1
No. 2	6,411.96	420.38	4.75	15.44	26.26	6.71	6,8
No. 3	10,520.79	233.56	2.64	8.58	14.59	3.73	10,7
No. 4	12,907.94	406.85	4.60	14.95	25.42	6.50	13,3
No. 5	7,152.07	17.00	.19	.63	1.06	.27	7,1
No. 6	.....	6,899.89	78.00	253.40	431.00	110.11	7,7
No. 7	.....	8,530.65	96.43	313.29	532.87	136.13	9,6
Aqueducts:							
No. 1	13,915.95	.....	.....	.....	.....	.....	13,9
No. 2	.....	136.93	1.55	5.03	8.55	2.19	1
Highway bridges:							
Mile 2	.....	1,971.12	22.28	72.39	123.12	31.46	2,2
Mile 5, No. 1	3,182.20	.....	.....	.....	.....	.....	3,1
Mile 5, No. 2	.....	1,663.96	18.81	61.11	103.94	26.56	1,8
Mile 7	.....	2,501.77	28.28	91.87	156.27	39.93	2,8
Mile 8	.....	2,381.39	26.92	87.46	148.75	38.00	2,6
Mile 13	.....	21.60	.25	.80	1.35	.35	
Mile 15	.....	340.93	3.85	12.52	21.29	5.44	3
Mile 16	.....	5,025.50	56.82	184.56	313.92	80.20	5,6
New highway, mile 16	.....	4,898.66	55.38	179.92	306.48	78.17	5,5
Houses:							
At lock No. 3	.....	1,854.51	20.96	68.11	115.84	29.60	2,0
At lock No. 6	.....	1,107.40	12.52	40.67	69.17	17.67	1,2
At lock No. 11	.....	1,555.30	17.58	57.12	97.15	24.82	1,7
At lock No. 13	.....	354.92	4.01	13.05	22.17	5.67	3
At lock No. 19	.....	1,689.70	19.10	62.07	105.55	26.97	1,9
On mile 23	.....	211.43	2.39	7.77	13.20	3.38	2
On mile 24	.....	170.95	1.93	6.29	10.68	2.73	1
Lock forming	3,324.20	4,566.62	.....	.....	.....	.....	9,8

Total cost to close of fiscal year 1898—Continued.

	At close of 1897.	Fiscal year 1898.	Deterioration of property and plant.	Equitable part of general construction.	Equitable part of superintendence and office.	Equitable part of care and repair.	Total.
Gravel pit		$9,722.48					$9,722.48
Telephone line		397.92					397.92
General construction	$13,000.00	29,308.95					28,000.00
Superintendence and office		24,338.60					
Care and repair of plant		6,217.87					
Property	12,823.18	9,199.11					17,617.83
Material (stock on hand)	16,120.32	30,408.21					30,408.21
		547,674.51					
Less material on hand June 30, 1897		16,120.32					
Total	619,491.90	531,554.19	$4,404.46	$14,308.95	$24,338.60	$6,217.87	1,151,046.09

Expenditures Illinois and Mississippi Canal for fiscal year 1898.

Eastern section	$531,554.19
Western section:	
Rock River division	470.21
Feeder Junction to Rock River	10,727.02
Feeder line	2,266.16
Total	545,017.58

Total expenditures Illinois and Mississippi Canal to end of fiscal year 1898.

Eastern section	$1,151,046.09
Western section:	
Around rapids of Rock River	547,229.93
Rock River division	470.21
Feeder Junction to Rock River	19,528.77
Feeder line	30,630.13
Total	1,748,905.13

List of contracts for construction of Illinois and Mississippi Canal in force during fiscal year ending June 30, 1898.

Name and address of contractor.	Nature of contract.	Date.	To expire.	Remarks.
Katz, Crandall & Callahan, Omaha, Nebr.	Earthwork, miles 9 to 16 inclusive.	June 19, 1897	July 1, 1898	Extended to Oct. 1, 1898.
Cogan & Pound, Chicago, Ill.	Pits and foundations for 11 locks and 2 aqueducts.	....do	....do	Extended to Sept. 30, 1898.
McArthur Bros. Co., Chicago, Ill.	2 concrete arch and 6 cast-iron pipe culverts.	....do	....do	Completed Dec. 8, 1897.
John J. McCaughey, Summit, Ill.	Earthwork, miles 17 and 18.	Oct. 6, 1897	Sept. 30, 1899	
Globe Construction Co., Cincinnati, Ohio.	Earthwork, miles 19, 20, 21, 22, 23.	....do	....do	
R. C. Cushing & Co., Chicago, Ill.	Earthwork, mile 24	....do	....do	
H. A. Boedker & Co., Chicago, Ill.	Pits and foundations, Locks 19, 20, and 21.	....do	....do	
The Toledo Bridge Co., Toledo, Ohio.	Superstructure 5 steel highway bridges.	Jan. 24, 1898	June 30, 1898	Extended to July 15, 1898.

Abstract of proposals for constructing 8 miles or less eastern section Illinois and Mississippi Canal, mile 17 to mile 24, excavating lock pits, and constructing foundations for three locks, and for constructing one concrete arch culvert, received in response to advertisement of August 23, 1897, and opened 12 m., central time, September 23, 1897, by Maj. W. L. Marshall, Corps of Engineers.

Number of proposal.	Name and address of bidder.	Mile 17.				
		Earthwork (142,000 cubic yards).		Stone paving (50 square yards).		Total.
		Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$0.15	$21,300.00	$2.50	$125.00	$21,425.00
10	John Scott & Sons, St. Louis, Mo	.129	18,318.00			
11	R. C. Cushing & Co., Chicago, Ill	.08	11,360.00	2.00	100.00	11,460.00
13	Callahan Construction Co., Omaha, Nebr	.0875	12,425.00	1.65	82.50	12,507.50
14	John J. McCaughey, Summit, Ill	.0698	9,911.60	1.60	80.00	9,991.60

Number of proposal.	Name and address of bidder.	Mile 18.				
		Earthwork (91,000 cubic yards).		Stone paving (50 square yards).		Total.
		Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$0.18	$16,380.00	$2.50	$125.00	$16,505.00
9	Samuel Sawtell, Omaha, Nebr	.0875	7,962.50			
10	John Scott & Sons, St. Louis, Mo	.129	11,739.00			
11	R. C. Cushing & Co., Chicago, Ill	.085	7,735.00	2.00	100.00	7,835.33
13	Callahan Construction Co., Omaha, Nebr	.085	7,735.00	1.65	82.50	7,817.50
14	John J. McCaughey, Summit, Ill	.0773	7,034.30	1.60	80.00	7,114.30

Number of proposal.	Name and address of bidder.	Mile 19.				
		Earthwork (172,000 cubic yards).		Stone paving (50 square yards).		Total.
		Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$0.20	$34,400.00	$2.50	$125.00	$34,525.00
5	Thos. Conley & Co., La Grange, Ill	.105	18,060.00	2.00	100.00	18,160.00
6	McArthur Bros. Co., Chicago, Ill	.125	21,500.00	2.00	100.00	21,600.00
10	John Scott & Sons, St. Louis, Mo	.17	29,240.00			
11	R. C. Cushing & Co., Chicago, Ill	.11	18,920.00	2.25	112.50	19,032.50
13	Callahan Construction Co., Omaha, Nebr	.11	18,920.00	1.65	82.50	19,002.50
14	John J. McCaughey, Summit, Ill	.15	25,800.00	1.75	87.50	25,887.50
15	Globe Construction Co., Cincinnati, Ohio	.097	16,684.00			

Number of proposal.	Name and address of bidder.	Mile 20.				
		Earthwork (364,000 cubic yards).		Stone paving (160 square yards).		Total.
		Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$0.35	$127,400.00	$2.50	$400.00	$127,800.00
5	Thos. Conley & Co., La Grange, Ill	.13	47,320.00	2.00	320.00	47,640.00
6	McArthur Bros. Co., Chicago, Ill	.24	87,360.00	2.00	320.00	87,680.00
9	Samuel Sawtell, Omaha, Nebr	.185	67,340.00			
10	John Scott & Sons, St. Louis, Mo	.225	81,900.00			
11	R. C. Cushing & Co., Chicago, Ill	.16	58,240.00	2.50	400.00	58,640.00
13	Callahan Construction Co., Omaha, Nebr	.18	65,520.00	1.65	264.00	65,784.00
14	John J. McCaughey, Summit, Ill	.225	81,900.00	1.80	288.00	82,188.00
15	Globe Construction Co., Cincinnati, Ohio	.0933	33,961.20			

Number of proposal.	Name and address of bidder.	Mile 21.				
		Earthwork (304,000 cubic yards).		Stone paving (50 square yards).		Total.
		Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$0.21	$63,840.00	$2.50	$125.00	$63,965.00
2	Heldmaier & New, Chicago, Ill	.1275	38,760.00	2.10	105.00	38,865.00
6	McArthur Bros. Co., Chicago, Ill	.24	72,960.00	2.00	100.00	73,060.00
7	Canal Construction Co., Chicago, Ill	.12	36,480.00			
10	John Scott & Sons, St. Louis, Mo	.24	72,960.00			
11	R. C. Cushing & Co., Chicago, Ill	.1575	47,880.00	2.50	125.00	48,005.00
13	Callahan Construction Co., Omaha, Nebr	.17	51,680.00	1.65	82.50	51,762.50
14	John J. McCaughey, Summit, Ill	.30	91,200.00	1.80	90.00	91,290.00
15	Globe Construction Co., Cincinnati, Ohio	.0933	28,363.20			

Abstract of proposals for constructing 8 miles or less eastern section Illinois and Mississippi Canal, etc.—Continued.

Number of proposal.	Name and address of bidder.	Mile 22. Earthwork (392,000 cubic yards).		Mile 23. Earthwork (176,000 cubic yards).		Mile 24. Earthwork (93,000 cubic yards).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.25	$98,000.00	$0.1925	$33,880.00	$0.57	$53,010.00
2	Heidmaier & New, Chicago, Ill	.135	52,920.00	.125	22,000.00	.....	.....
6	McArthur Bros. Co., Chicago, Ill	.24	94,080.00	.....	.....	.....	.....
7	Canal Construction Co., Chicago, Ill	.149	58,408.00	.129	22,704.00	.....	.....
9	Samuel Sawtell, Omaha, Nebr	.2225	87,220.00	.235	41,360.00	.17	15,810.00
10	John Scott & Sons, St. Louis, Mo	.27	105,840.00	.225	39,600.00	.18	16,740.00
11	R. C. Cushing & Co., Chicago, Ill	.22	86,240.00	.17	29,920.00	.089	8,277.00
13	Callahan Construction Co., Omaha, Nebr.	.24	94,080.00	.25	44,000.00	.20	18,600.00
14	John J. McCaughey, Summit, Ill	.275	107,800.00	.30	52,800.00	.15	13,950.00
15	Globe Construction Co., Cincinnati, Ohio.	.0933	36,573.60	.0933	16,420.80	.....	.....

FOUNDATION FOR LOCK NO. 19.

Number of proposal.	Name and address of bidder.	Earth excavation (22,000 cubic yards).		Piles (363).		Pine timber (50,000 feet B. M.).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.20	$4,400.00	$3.25	$1,179.75	$24.20	$1,210.00
13	Callahan Construction Co., Omaha, Nebr.	.15	3,300.00	3.65	1,324.95	21.50	1,075.00

Number of proposal.	Name and address of bidder.	Pine plank (15,000 feet B. M.).		Oak plank (13,000 feet B. M.).		Spikes, bolts, and nails (5,500 pounds).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$21.50	$322.50	$45.00	$585.00	$0.03	$165.00
13	Callahan Construction Co., Omaha, Nebr.	21.00	315.00	38.00	494.00	.02	110.00

Number of proposal.	Name and address of bidder.	Concrete. Natural cement (925 cubic yards).		Portland cement with pebbles (50 cubic yards).		Portland cement with broken stone (50 cubic yards).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$3.25	$3,006.25	$6.00	$300.00	$8.00	$400.00
13	Callahan Construction Co, Omaha, Nebr.	3.40	3,145.00	5.00	250.00	5.50	275.00

Number of proposal.	Name and address of bidder.	Gravel (300 cubic yards).		8-inch drain pipe (210 linear feet).		10-inch drain pipe (560 linear feet).		Total.
		Price.	Amount.	Price.	Amount.	Price.	Amount.	
1	Cogan and Pound, Chicago, Ill	$0.70	$210.00	$0.20	$42.00	$0.25	$140.00	$11,560.50
12	Callahan Construction Co., Omaha, Nebr	.70	210.00	.125	26.25	.15	84.00	10,334.20

Abstract of proposals for constructing 8 miles or less eastern section Illinois and Mississippi Canal, etc.—Continued.

FOUNDATION FOR LOCK NO. 20.

Number of proposal.	Name and address of bidder.	Earth excavation (10,600 cubic yards).		Piles (363).		Pine timber (50,000 feet B. M).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.30	$3,180.00	$4.00	$1,452.00	$24.20	$1,210.00
13	Callahan Construction Co., Omaha, Nebr.	0.15	1,590.00	3.65	1,324.95	21.50	1,075.00

Number of proposal.	Name and address of bidder.	Pine plank (15,000 feet B. M.).		Oak plank (13,000 feet B. M.).		Spikes, bolts, and nails (5,500 pounds).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$21.50	$322.50	$45.00	$585.00	$.03	$165.00
13	Callahan Construction Co., Omaha, Nebr.	21.00	315.00	38.00	494.00	.02	110.00

Number of proposal.	Name and address of bidder.	Concrete.					
		Natural cement (925 cubic yards).		Portland cement with pebbles (50 cubic yards).		Portland cement with broken stone (50 cubic yards).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$3.50	$3,237.50	$6.50	$325.00	$8.50	$425.00
13	Callahan Construction Co., Omaha, Nebr.	3.40	3,145.00	5.00	250.00	5.50	275.00

Number of proposal.	Name and address of bidder.	Gravel (300 cubic yards).		8-inch drain-pipe (210 linear feet).		10-inch drain-pipe (560 linear feet).		Total.
		Price.	Amount.	Price.	Amount.	Price.	Amount.	
1	Cogan & Pound, Chicago, Ill	$1.00	$300.00	$0.20	$42.00	$0.25	$140.00	$10,959.00
13	Callahan Construction Co., Omaha, Nebr.	0.70	210.00	0.125	26.25	0.15	84.00	8,624.20

FOUNDATION FOR LOCK NO. 21.

Number of proposal.	Name and address of bidder.	Earth excavation (12,200 cubic yards).		Piles (363).		Pine timber (50,000 feet B. M.).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.20	$2,440.00	$3.25	$1,179.75	$24.20	$1,210.00
13	Callahan Construction Co., Omaha, Nebr.	.15	1,830.00	3.65	1,324.95	21.50	1,075.00

Number of proposal.	Name and address of bidder.	Pine plank (15,000 feet B. M.).		Oak plank (13,000 feet B. M.).		Spikes, bolts, and nails (5,500 pounds).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$21.50	$322.50	$45.00	$585.00	$0.03	$165.00
13	Callahan Construction Co., Omaha, Nebr.	21.00	315.00	38.00	494.00	.02	110.00

Abstract of proposals for constructing 8 miles or less eastern section Illinois and Mississippi Canal, etc.—Continued.

FOUNDATION FOR LOCK No. 21—Continued.

Number of proposal.	Name and address of bidder.	Concrete.					
		Natural cement (925 cubic yards).		Portland cement with pebbles (50 cubic yards).		Portland cement with broken stone (50 cubic yards).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$3.50	$3,237.50	$6.50	$325.00	$8.50	$425.00
13	Callahan Construction Co., Omaha, Nebr.	3.40	3,145.00	5.00	250.00	5.50	275.00

Number of proposal.	Name and address of bidder.	Gravel (300 cubic yards).		8-inch drain-pipe (210 linear feet).		10-inch drain-pipe (560 linear feet).		Total.
		Price.	Am't.	Price.	Am't.	Price.	Am't.	
1	Cogan & Pound, Chicago, Ill	$1.00	$300.00	$0.20	$42.00	$0.25	$140.00	$9,946.75
13	Callahan Construction Co., Omaha, Nebr.	.70	210.00	.125	26.25	.15	84.00	8,864.20

FOUNDATIONS FOR THREE LOCKS.

Number of proposal.	Name and address of bidder.	Earth excavation (44,800 cubic yards).		Piles (1,089).		Pine timber (150,000 feet B.M.).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.175	$7,840.00	$3.25	$3,539.25	$22.20	$3,330.00
3	Dean & Tolman, Aurora, Ill	.15	6,720.00	3.35	3,648.15	23.00	3,450.00
4	Barron & Peace, Marseilles, Ill	.18	8,064.00	3.40	3,702.60	21.00	3,150.00
6	McArthur Brothers Co., Chicago, Ill	.34	15,232.00	4.00	4,356.00	25.00	3,750.00
8	Chicago Star Construction and Dredging Co., Illinois	.17	7,616.00	3.00	3,267.00	22.00	3,300.00
12	H. A. Boedker & Co., Chicago, Ill	.16	7,168.00	3.25	3,539.25	22.00	3,300.00
12	Callahan Construction Co., Omaha, Nebr.	.15	6,720.00	3.65	3,974.85	21.50	3,225.00
16	Lydon & Drews Co., Chicago, Ill	.16	7,168.00	3.50	3,811.50	21.00	3,150.00

Number of proposal.	Name and address of bidder.	Pine plank (45,000 feet B. M.).		Oak plank (39,000 feet B. M.).		Spikes, bolts, and nails (16,500 pounds).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$22.20	$999.00	$40.00	$1,560.00	$0.03	$495.00
3	Dean & Tolman, Aurora, Ill	23.00	1,035.00	45.00	1,755.00	.03	495.00
4	Barron & Peace, Marseilles, Ill	20.00	900.00	40.00	1,560.00	.025	412.50
6	McArthur Brothers Co., Chicago, Ill	25.00	1,125.00	48.00	1,872.00	.03	495.00
8	Chicago Star Construction and Dredging Co., Illinois	20.00	900.00	50.00	1,950.00	.03	495.00
12	H. A. Boedker & Co., Chicago, Ill	20.00	900.00	40.00	1,560.00	.0225	371.25
13	Callahan Construction Co., Omaha, Nebr.	21.00	945.00	38.00	1,482.00	.02	330.00
16	Lydon & Drews Co., Chicago, Ill	21.00	945.00	40.00	1,560.00	.025	412.50

Number of proposal.	Name and address of bidder.	Concrete.					
		Natural cement (2,775 cubic yards).		Portland cement with pebbles (150 cubic yards).		Portland cement with broken stone (150 cubic yards).	
		Price.	Amount.	Price.	Amount.	Price.	Amount.
1	Cogan & Pound, Chicago, Ill	$3.00	$8,325.00	$5.00	$750.00	$8.00	$1,200.00
3	Dean & Tolman, Aurora, Ill	2.95	8,186.25	5.00	750.00	8.00	1,200.00
4	Barron & Peace, Marseilles, Ill	3.25	9,018.75	5.00	750.00	6.00	900.00
6	McArthur Brothers Co., Chicago, Ill	3.25	9,018.75	7.00	1,050.00	8.50	1,275.00
8	Chicago Star Construction and Dredging Co., Illinois	3.00	8,325.00	5.00	750.00	7.00	1,050.00
12	H. A. Boedker & Co., Chicago, Ill	2.80	7,770.00	5.00	750.00	6.75	1,012.50
13	Callahan Construction Co., Omaha, Nebr.	3.40	9,435.00	5.00	750.00	5.50	825.00
16	Lydon & Drews Co., Chicago, Ill	3.00	8,325.00	5.00	750.00	6.00	900.00

Abstract of proposals for constructing 8 miles or less eastern section Illinois and Mississippi Canal, etc.—Continued.

FOUNDATIONS FOR THREE LOCKS—Continued.

Number of proposal.	Name and address of bidder.	Gravel (900 cubic yards).		8-inch drain pipe (630 linear feet).		10-inch drain pipe (1,680 linear feet).		Total.
		Price.	Am't.	Price.	Am't.	Price.	Am't.	
1	Cogan & Pound, Chicago, Ill	$0.75	$675.00	$0.10	$63.00	$0.15	$252.00	$27,828.25
3	Doan & Tolman, Aurora, Ill	.65	585.00	.12	75.60	.15	252.00	26,952.00
4	Barron & Peace, Marseilles, Ill	.60	540.00	.13	81.90	.18	302.40	28,482.15
6	McArthur Brothers Co., Chicago, Ill	.60	540.00	.15	94.50	.20	336.00	37,869.25
8	Chicago Star Construction and Dredging Co., Illinois	1.00	900.00	.15	94.50	.25	420.00	28,017.50
12	H. A. Boedker & Co., Chicago, Ill	.50	450.00	.15	94.50	.20	336.00	26,239.00
13	Callahan Construction Co., Omaha, Nebr	.70	630.00	.125	78.75	.15	252.00	27,822.60
16	Lydon & Drews Co., Chicago, Ill	1.00	900.00	.16	100.80	.20	336.00	27,458.80

ONE CONCRETE ARCH CULVERT.

Number of proposal.	Name and address of bidder.	Earthwork (7,500 cubic yards).		Piles (130).		Pine timber (15,000 feet B. M.).	
		Price.	Amount.	Price each.	Amount.	Price per M.	Amount.
1	Cogan & Pound, Chicago, Ill	$0.75	$5,625.00	$6.00	$780.00	$30.00	$450.00

Number of proposal.	Name and address of bidder.	Pine plank (5,300 feet B. M.).		Oak plank (1,400 feet B. M.).		Driftbolts, etc. (1,700 pounds).	
		Price per M.	Amount.	Price per M.	Amount.	Price per pound.	Amount.
1	Cogan & Pound, Chicago, Ill	$30.00	$159.00	$50.00	$70.00	$0.03	$51.00

Number of proposal.	Name and address of bidder.	Concrete.					
		Natural cement (160 cubic yards).		Portland cement with pebbles (430 cubic yards).		Portland cement with broken stone (430 cubic yards).	
		Price per cubic yard.	Amount.	Price per cubic yard.	Amount.	Price per cubic yard.	Amount.
1	Cogan & Pound, Chicago, Ill	$5.00	$800.00	$9.00	$3,870.00	$12.00	$5,160.00

Number of proposal.	Name and address of bidder.	Rubble paving stone (190 square yards).		Total.
		Price per square yard.	Amount.	
1	Cogan & Pound, Chicago, Ill	$2.50	$475.00	$12,280.00

REMARKS.

The price of Portland-cement concrete with broken stone not included in total cost of lock foundation. Proposal No. 15 does not include cost of slope paving miles 19, 20, and 21.

Proposals Nos. 1, 2, 5, and 11. No witness to signature.

Proposal No. 7. No witness to signature. Date of beginning work not stated.

Proposal No. 13. No witness to signature. No corporate seal. Date of beginning work not stated.

Proposal No. 14. No witness to signature. Date of beginning work not stated.

No.										
1	The Toledo Bridge Co., Toledo, Ohio a	Low truss, steel riveted.	$1,640	$1,640	$1,640	$1,640	$1,640	$8,200	Good design, riveted Warren truss, but violating paragraphs 106, 120, and 131. These are minor violations that can readily be corrected.	12
2	The La Fayette Bridge Co., Lafayette, Ind.	Lattice	1,290	1,300	1,300	1,295	1,280	6,465	Plan A. Undesirable knee bracing: Violates paragraph 95.	5
		Riveted, plate girder..	2,150	2,165	2,165	2,155	2,110	10,745	Plan B. Plate girder: Violates paragraph 95; inside knee braces.	15
3	The King Bridge Co., Cleveland, Ohio	Steel, standard connections.	2,600	2,600	2,600	2,600	2,600	13,000	Handsome, well-braced design: Complies with specification.	17
4	Fort Pitt Bridge Works, Pittsburg, Pa ...	Low truss, either pin or rivet.	2,480	2,500	2,500	2,490	2,470	12,440	Undesirable knee bracing: Violates paragraph 133.	16
5	Alonzo J. Tullock, Leavenworth, Kans....	Medium pin	1,470	1,470	1,470	1,470	1,470	7,350	No knee bracing: Violates paragraph 95.....	10
6	Stupp Bros. Bridge and Iron Co., St. Louis, Mo.	High truss	1,348	1,348	1,348	1,348	1,348	6,740	Design not suitable: Violates paragraph 95.....	8
7	Wisconsin Bridge and Iron Co., North Milwaukee, Wis.	Steel low truss, pin ..	1,157	1,167	1,167	1,157	1,157	5,805	Undesirable knee bracing: Violates paragraph 95. Plan A.	1
		Lattice	1,197	1,207	1,207	1,197	1,197	6,005	Undesirable knee bracing: Violates paragraph 95. Plan B.	2
8	J. G. Wagner Co., Milwaukee, Wis.....	Low truss, rivets.....	1,330	1,330	1,330	1,330	1,330	6,650	Unsuitable design: Violates paragraphs 95 and 133.	7
9	Massillon Bridge Co., Massillon, Ohio.....	Not stated.....	1,270	1,270	1,270	1,270	1,270	6,350	Plan A. Violates paragraphs 92, 95, 104, 131, and 133.	4
			1,300	1,300	1,300	1,300	1,300	6,500	Plan B. Undesirable design: Violates paragraph 131.	6
10	Joliet Bridge and Iron Co., Joliet, Ill	Steel low truss, riveted.	1,545	1,545	1,545	1,545	1,545	7,725	Violates paragraphs 95 and 131	11
11	The Youngstown Bridge Co., Youngstown, Ohio.	Medium steel, pins or rivets.	1,370	1,370	1,370	1,370	1,370	6,850	Violates paragraph 95: Knee bracing not desirable.	9
12	Penn Bridge Co., Beaver Falls, Pa	Steel low truss, riveted.	2,045	2,045	2,045	2,045	2,045	10,225	Good design: Violates paragraph 95.....	14
13	Pittsburgh Bridge Co., Pittsburg, Pa.....	Medium steel pony truss, riveted.	1,950	1,950	1,950	1,950	1,950	9,750	Pratt truss; good design and stiff bracing: Complies with specification.	13
14	Kenwood Bridge Co., Chicago, Ill.....	Soft steel pony truss, riveted.	1,261	1,261	1,261	1,261	1,261	6,305	Violates paragraphs 39 and 95	3

a Contract awarded.

There is available for this work, $15,000.

REPORT OF MR. JAS. C. LONG, ASSISTANT ENGINEER.

TISKILWA, ILL., *July 1, 1898.*

MAJOR: I have the honor to submit the following report of operations on the work under my supervision comprising the eastern section of the Illinois and Mississippi Canal, extending from mile 1, on the west bank of the Illinois River 1½ miles east of Bureau Junction, Illinois, to mile 27.8, at the feeder junction, for the fiscal year ending June 30, 1898.

CONDITION OF THE WORK AT BEGINNING OF FISCAL YEAR.

The line of canal has been definitely located from mile 1, at the Illinois River, to mile 27.8, at the feeder junction. The right of way on the first 24 miles condemned 16 miles paid for, and inclosed with a barbed-wire fence.

Earthwork on canal trunk for first 8 miles, except entrances to locks and approaches to bridges, and all masonry on the first 8 miles, excepting bridges, completed. Storage yards established at Bureau Junction, Locks 3 and 6, and connected with the Chicago, Rock Island and Pacific Railway by standard-gauge side track. A narrow-gauge railway track built along canal embankment from Lock 1, on mile 1, to Lock 7, on mile 8, and connected by 1½ miles of additional narrow-gauge track with all the storage yards, gravel pit, and lock sites. A house to shelter locomotives, a blacksmith shop, an oil house, a warehouse at Lock 2, three in the storage yard at Lock 3, and another in the storage yard at Lock 6, built. Land acquired adjacent to the right of way near Lock 4 and the gravel pit opened on same for the purpose of furnishing gravel for the construction of concrete masonry.

CONTRACT WORK.

The following abstract shows the contracts in force during the fiscal year:

Abstracts of contracts for constructing eastern section of Illinois and Mississippi Canal in force during the fiscal year ending June 30, 1898.

Name and address of contractors.	Nature of contract.	Date.	To expire.
Katz, Crandall & Callahan, Omaha, Nebr.	Earthwork, miles 9 to 16 inclusive ..	June 19, 1897	July 1, 1898 extended to Oct. 1 1898.
Cogan & Pound, Chicago, Ill	Pits and foundations for 11 locks and 2 aqueducts.	June 19, 1897	July 1, 1898 extended to Oct. 1 1898.
McArthur Bros., Chicago, Ill.....	2 concrete arch and 6 cast-iron pipe culverts.	June 19, 1897	July 1, 1898.
John J. McCaughey, Summit, Ill ...	Earthwork, miles 17 and 18	Oct. 6, 1897	Sept. 30, 1898
Globe Construction Co., Cincinnati, Ohio.	Earthwork, miles 19 to 23.....	Oct. 6, 1897	Sept. 30, 1898
R. C. Cushing & Co., Chicago, Ill....	Earthwork, mile 24	Oct. 6, 1897	Sept. 30, 1898
H. A. Boedker & Co., Chicago, Ill...	Pits and foundations, Locks 19 to 21.	Oct. 6, 1897	Sept. 30, 1898
Toledo Bridge Co., Toledo, Ohio.....	5 steel highway bridges, Nos. 1, 2, 3, 4, and 10.	Jan. 24, 1898	June 30, 1898

CONTRACT WORK DONE DURING FISCAL YEAR.

Canal trunk, miles 9 to 16, Katz, Crandall & Callahan, contractors.

Mile 9 (completed):		
134,270 cubic yards earthwork, at 8½ cents	$11,077.27	
5,435 cubic yards hard excavation, at 60 cents	3,261.00	
Total work on mile		$14,338.27
Mile 10 (completed):		
122,761 cubic yards earthwork, at 8½ cents	10,127.78	
425 cubic yards hard excavation, at 60 cents	255.00	
3,096 square yards slope paving, $1.25	3,870.00	
Total work on mile		14,252.78
Mile 11 (completed):		
151,712 cubic yards earthwork, at 8½ cents	12,516.25	
5,445 square yards slope paving, $1.25	6,806.25	
Total work on mile		19,322.50

Mile 12 (completed):		
109,428 cubic yards earthwork, at 8½ cents	$9,027.81	
Total work on mile		$9,027.81
Mile 13 (completed):		
135,682 cubic yards earthwork, at 8½ cents	11,193.77	
6,602 cubic yards hard excavation, at 60 cents	3,961.20	
Total work on mile		15,154.97
Mile 14 (completed):		
107,342 cubic yards earthwork, at 8½ cents	8,855.71	
545 cubic yards hard excavation, at 60 cents	327.00	
Total work on mile		9,182.71
Mile 15 (98 per cent completed):		
221,300 cubic yards earthwork, at 8½ cents	18,257.25	
57,700 cubic yards hard excavation, at 60 cents	34,620.00	
Total work on mile to date		52,877.25
Mile 16 (90 per cent completed):		
231,960 cubic yards earthwork, at 8½ cents	19,146.70	
40,015 cubic yards hard excavation, at 60 cents	24,009.00	
Total work on mile to date		43,145.70
Total amount of work done by above contractors		177,301.99

Canal trunk, miles 17 and 18, John J. McCaughey, contractor.

Mile 17 (4 per cent completed):		
5,950 cubic yards earthwork, at 6.98 cents	$415.31	
Total work on mile to date		$415.31
Mile 18 (66 per cent completed):		
63,460 cubic yards earthwork, at 7.73 cents	4,905.46	
Total work on mile to date		4,905.46
Total amount of work done by above contractor		5,320.77

Canal trunk, miles 19 to 23, Globe Construction Company, contractors.

Mile 19 (43 per cent completed):		
66,279 cubic yards of earthwork, at 9.7 cents	$6,429.06	
18,281 cubic yards hard excavation, at 60 cents	10,968.60	
Total amount of work on mile to date		$17,397.66
Total amount of work done by above contractors		17,397.66

No work has been done on canal trunk, miles 20 to 24, inclusive.

Pits and foundations for 11 locks and 2 aqueducts, Cogan & Pound, contractors.

Lock pit and foundation No. 8 (completed):	
6,425 cubic yards excavation, at 15 cents	$963.75
363 piles, at $3.25	1,179.75
49,688 feet B. M. pine timber, at $22.20	1,003.07
13,864 feet B. M. pine plank, at $22.20	307.78
12,771 feet B. M. oak plank, at $29.40	375.47
5,714 pounds spikes and drift bolts, at 2 cents	114.28
920 cubic yards natural cement concrete, at $3.10	2,852.00
47 cubic yards Portland cement concrete, at $9.60	310.20
183 cubic yards gravel, at 60 cents	109.80
274 linear feet 8-inch drainpipe, at 10 cents	27.40
214 linear feet 10-inch drainpipe, at 15 cents	32.10
Total cost of foundation	$7,275.60
Lock pit and foundation No. 9 (completed):	
1,523 cubic yards excavation, at 15 cents	228.45
363 piles, at $3.25	1,179.75
49,688 feet B. M. pine timber, at $22.20	1,002.63

Lock pit and foundation No. 9 (completed)—Continued.		
12,796 feet B. M. pine plank, at $22.20	$284.07	
12,771 feet B. M. oak plank, at $29.40	375.47	
4,977 pounds spikes, bolts, etc., at 2 cents	99.54	
919 cubic yards natural cement concrete, at $3.10	2,848.90	
47 cubic yards Portland cement concrete, at $6.60	310.20	
178 cubic yards gravel, at 60 cents	106.80	
210 linear feet 8-inch drainpipe, at 10 cents	21.00	
308 linear feet 10-inch drainpipe, at 15 cents	46.20	
Total cost of foundation		$6,503.0
Lock pit and foundation No. 10 (completed):		
343 cubic yards excavation, at 15 cents	501.45	
363 piles, at $3.25	1,179.75	
49,668 feet B. M. pine timber, at $22.20	1,002.63	
13,864 feet B. M. pine plank, at $22.20	307.78	
12,771 feet B. M. oak plank, at $29.40	375.47	
5,714 pounds spikes, bolts, etc., at 2 cents	114.28	
920 cubic yards natural cement concrete, at $3.10	2,852.00	
47 cubic yards Portland cement concrete, at $6.60	310.20	
183 cubic yards gravel, at 60 cents	109.80	
274 linear feet 8-inch drainpipe, at 10 cents	27.40	
214 linear feet 10-inch drainpipe, at 15 cents	32.10	
Total cost of foundation		6,812.8
Lock pit and foundation No. 11 (completed):		
11,372 cubic yards excavation, at 15 cents	1,705.80	
363 piles, at $3.25	179.75	
49,668 feet B. M. pine timber, at $22.20	1,002.63	
13,864 feet B. M. pine plank, at $22.20	307.78	
12,771 feet B. M. oak plank, at $29.40	375.47	
5,714 pounds spikes, bolts, etc., at 2 cents	114.28	
928 cubic yards natural cement concrete, at $3.10	2,876.80	
47 cubic yards Portland cement concrete, at $6.60	310.20	
274 linear feet 8-inch drainpipe, at 10 cents	27.40	
114 feet 10-inch drainpipe, at 15 cents	32.10	
183 cubic yards gravel, at 60 cents	109.80	
Total cost of foundation		8,042.0
Lock pit and foundation No. 12 (completed):		
5,154 cubic yards excavation, at 15 cents	773.10	
445 piles, at $3.25	1,446.25	
66,000 feet B. M. pine timber, at $22.20	1,243.20	
15,000 feet B. M. pine plank, at $22.20	1,333.00	
12,870 feet B. M. oak plank, at $29.40	378.38	
5,500 pounds spikes, bolts, etc., at 2 cents	110.00	
1,020 cubic yards natural cement concrete, at $3,10	3,162.00	
41.5 cubic yards Portland cement concrete, at $6.60	273.90	
Total cost of foundation		7,719.8
Lock pit and foundation No. 13 (completed):		
2,775 cubic yards excavation, at 15 cents	416.25	
363 piles, at $3.25	1,179.75	
49,647 feet B. M. pine timber, at $22.20	1,102.16	
14,040 feet B. M. pine plank, at $22.20	311.69	
12,229 feet B. M. oak plank, at $29.40	359.53	
5,325 pounds spikes and bolts, at 2 cents	106.50	
904 cubic yards natural cement, at $3.10	2,802.40	
41.5 cubic yards Portland cement, at $6.60	273.90	
190 linear feet 8-inch drainpipe, at 10 cents	19.00	
350 linear feet 10-inch drainpipe, at 15 cents	52.50	
60 cubic yards gravel, at 60 cents	36.00	
Total cost of foundation		6,659.6
Lock pit and foundation No. 14 (completed):		
6,420 cubic yards excavation, at 15 cents	963.00	
138 cubic yards hard excavation, at 60 cents	82.80	
363 piles, at $3.25	1,179.75	
49,647 feet B. M. pine timber, at $22.20	1,102.16	
13,500 feet B. M. pine plank, at $22.20	299.70	

Lock pit and foundation No. 14 (completed)—Continued.		
12,447 feet B. M. oak plank, at $29.40	$365.94	
5,325 pounds spikes and bolts, at 2 cents	106.50	
904 cubic yards natural cement concrete, at $3.10	2,802.40	
41.5 cubic yards Portland cement concrete, at $6.60	273.90	
190 linear feet 8-inch drainpipe, at 10 cents	19.00	
260 linear feet 10-inch drainpipe, at 15 cents	39.00	
110 cubic yards gravel, at 60 cents	66.00	
Total cost of foundation		$7,300.15
Lock pit and foundation No. 15 (incomplete):		
4,681 cubic yards excavation, at 15 cents	747.15	
68 cubic yards hard excavation, at 60 cents	40.80	
363 piles, at $3.25	1,179.75	
49,539 feet B. M. pine timber, at $22.20	1,099.77	
800 feet B. M. pine plank, at $22.20	17.76	
4,500 pounds spikes and bolts, at 2 cents	90.00	
750 cubic yards natural cement concrete, at $3.10	2,325.00	
41.5 cubic yards Portland cement concrete, at $6.60	273.90	
Total cost of foundation to date		5,774.13
Lock pit and foundation No. 16 (incomplete):		
1,577 cubic yards excavation, at 15 cents	236.55	
363 piles, at $3.25	1,179.75	
13,000 feet B. M. pine timber, at $22.20	288.60	
12,500 feet B. M. oak plank, at 29.40	367.50	
1,500 pounds spikes and bolts, at 2 cents	30.00	
Total cost of foundation to date		2,102.40
Lock pit and foundation No. 17 (incomplete):		
7,528 cubic yards excavation, at 15 cents	1,129.20	
347 cubic yards hard excavation, at 60 cents	208.20	
Total cost of foundation to date		1,337.40
Lock pit and foundation No. 18 (incomplete):		
7,500 cubic yards excavation, at 15 cents	1,125.00	
8,150 cubic yards hard excavation, at 60 cents	4,890.00	
Total cost of foundation to date		6,015.00
Foundation of Aqueduct No. 2 (incomplete):		
2,631 cubic yards excavation, at 15 cents	394.65	
362 piles, at $3.25	1,274.00	
22,000 feet B. M. pine timber, at $22.20	488.40	
2,400 pounds bolts, spikes, etc., at 2 cents	48.00	
125 cubic yards Portland cement concrete, at $6.60	1,221.00	
Total cost of foundation		3,426.05
Total cost of work done by above contractors		69,068.12

Lock pits and foundations for three locks, H. A. Boedker & Co., contractors.

Lock pit and foundation No. 19 (complete):		
26,754 cubic yards excavation, at 16 cents	$4,280.00	
37 cubic yards hard excavation, at 60 cents	22.20	
363 piles, at $3.25	1,179.75	
49,663 feet B. M. pine timber, at $22	1,092.58	
13,888 feet B. M. pine plank, at $20	277.76	
12,816 feet B. M. oak plank, at $40	512.64	
5,640 pounds spikes and bolts, at 2½ cents	126.90	
895 cubic yards natural cement concrete, at $2.80	2,506.00	
47 cubic yards Portland cement concrete, at $5	235.00	
104 cubic yards gravel, at 50 cents	52.00	
195 linear feet 8-inch drainpipe, at 15 cents	29.25	
254 linear feet 10-inch drainpipe, at 20 cents	50.80	
Total cost of foundation		$10,364.88
Lock pit and foundation No. 20 (incomplete):		
11,625 cubic yards excavation, at 16 cents	1,860.00	
510 piles, at $3.25	1,657.50	

Lock pit and foundation No. 20 (incomplete)—Continued.		
12,500 feet B. M. pine timber, at $22	$275.00	
2,772 feet B. M. oak plank, at $40	110.88	
1,400 pounds spikes and bolts, at 2½ cents	31.50	
Total cost of foundation		$3,934.88
Lock pit and foundation No. 21 (completed):		
12,784 cubic yards excavation, at 16 cents	2,045.44	
511 piles, at $3.25	1,660.00	
58,680 feet B. M. pine timber, at $22	1,290.96	
13,888 feet B. M. pine plank, at $20	277.76	
12,816 feet B. M. oak plank, at $40	512.64	
7,519 pounds spikes and bolts, at 2½ cents	169.17	
913 cubic yards natural cement concrete, at $2.80	2,556.40	
45 cubic yards Portland cement concrete, at $5	225.00	
104 cubic yards gravel, at 50 cents	52.00	
200 linear feet 8-inch drainpipe, at 15 cents	30.00	
254 linear feet 10-inch drainpipe, at 20 cents	50.80	
Total cost of foundation		8,870.17
Total cost of work done by above contractors		23,169.93

Two concrete arch and 6 cast iron pipe culverts, McArthur Brothers, contractors (all completed).

12-foot concrete arch culvert No. 6:		
4,373 cubic yards excavation, at 34 cents	$1,486.82	
130 piles, at $3.90	507.00	
14,736 feet B. M. pine timber, at $25	368.40	
5,184 feet B. M. pine plank, at $23	119.23	
1,496 feet B. M. oak plank, at $50	74.80	
1,500 pounds spikes, bolts, etc., at 2½ cents	37.50	
160 cubic yards natural cement concrete, at $3	480.00	
519.87 cubic yards Portland cement concrete, at $6.85	3,561.11	
80 square yards stone paving, at $1.50	120.00	
Total cost of culvert		$6,754.86
10-foot double concrete arch culvert No. 7:		
4,916 cubic yards excavation, at 34 cents	1,671.44	
518 cubic yards hard excavation, at 60 cents	310.80	
219 piles, at $3.90	854.10	
22,640 feet B. M. pine timber, at $25	566.00	
8,640 feet B. M. pine plank, at $23	198.72	
992 feet B. M. oak plank, at $50	49.60	
2,862 pounds spikes, bolts, etc., at 2½ cents	71.55	
278 cubic yards natural cement concrete, at $3	834.00	
498 cubic yards Portland cement concrete, at $6.85	3,411.30	
256 square yards stone paving, at $1.50	384.00	
Total cost of culvert		8,351.51
Double 48-inch cast iron pipe culvert No. 5:		
926 cubic yards excavation, at 34 cents	314.84	
121.5 cubic yards natural cement concrete, at $3	364.50	
132 square yards stone paving, at $1.50	198.00	
51 cubic yards rubble masonry, at $6	306.00	
288 linear feet cast-iron pipe, at $6.20	1,785.60	
Total cost of culvert		2,968.94
Pipe culvert No. 6 dispensed with.		
48-inch cast iron pipe culvert No. 7:		
1,203 cubic yards excavation, at 34 cents	409.02	
51 cubic yards hard excavation, at 60 cents	30.60	
64 cubic yards natural cement concrete, at $3	192.00	
156 square yards stone paving, at $1.50	234.00	
38 cubic yards rubble masonry, at $6	228.00	
144 linear feet 48-inch cast-iron pipe, at $6.20	892.80	
Total cost of culvert		1,986.42

Forty-eight inch cast-iron pipe culvert No. 8:		
1,421 cubic yards excavation, at 34 cents	$483.14	
27 cubic yards hard excavation, at 60 cents	16.20	
79 cubic yards natural cement concrete, at $3	237.00	
147 square yards stone paving, at $1.50	220.50	
28 cubic yards rubble masonry, at $6	168.00	
192 linear feet 48-inch cast-iron pipe, at $6.20	1,190.40	
Total cost of culvert		$2,315.24
Thirty-six inch cast-iron pipe culvert No. 9:		
807 cubic yards excavation, at 34 cents	274.38	
50 cubic yards natural cement concrete, at $3	150.00	
124 square yards stone paving, at $1.50	186.00	
17 cubic yards rubble masonry, at $6	102.00	
144 linear feet 36-inch cast-iron pipe, at $4.20	604.80	
Total cost of culvert		1,317.18
Forty-eight inch cast-iron pipe culvert No. 10:		
839 cubic yards excavation, at 34 cents	285.26	
58 cubic yards natural cement concrete, at $3	174.00	
102 square yards stone paving, at $1.50	153.00	
29 cubic yards rubble masonry, at $6	174.00	
144 linear feet 48-inch cast-iron pipe, at $6.20	892.80	
Total cost of culvert		1,679.06
Forty-eight inch cast-iron pipe culvert No. 11:		
946 cubic yards excavation, at 34 cents	321.64	
43.7 cubic yards natural cement concrete, at $3	131.10	
105 square yards stone paving, at $1.50	157.50	
21 cubic yards rubble masonry, at $6	126.00	
144 linear feet 48-inch cast-iron pipe, at $6.20	604.80	
Total cost of culvert		1,341.04
Total cost of work done by above contractors		26,714.25

Superstructures for five steel highway bridges. Toledo Bridge Co., contractors. (Contract partly completed.)

Contract price, $1,640 for each bridge.
Bridge No. 1 not yet erected.
Bridge No. 2 not yet erected.

Bridge No. 3, material on the ground; paid two-thirds of contract price, less 10 per cent	$989.00
Bridge No. 4, material on ground; paid two-thirds contract price, less 10 per cent	989.00
Bridge No. 10, material on ground; paid two-thirds contract price, less 10 per cent	989.00
Amount paid on contract	2,967.00

WORK DONE BY HIRED LABOR.

Concrete masonry.—This work on locks and highway-bridge abutments was done by hired labor. The concrete for abutments was mixed by hand, but that for locks was mixed by machinery. Two 4-foot cubical mixers were used, each with the necessary hoisting machinery, being operated by a portable engine. One of these mixers was operated at a lock under construction while the other was being set up at another lock site, so as to save time and keep the force constantly at work. Extra forming, about enough for 2½ locks, was also used for the same reason, and was set up in advance while the forms at one lock were being filled.

As the construction of concrete masonry for the locks requires that it should progress constantly, three shifts of labor, working eight hours each, were kept at work from the time the walls were started until they were completed, except on the Sabbath, when work was suspended. When work was to be suspended a section of the walls, which are built in sections 20 feet long, was carried to completion, and a new section was started when work was resumed.

Working plans were furnished me from your office, together with a pamphlet containing general instructions for the construction of concrete masonry of locks,

covering organization, proportions and mixing of concrete, depositing and ramming concrete, delivery of material, records, reports, and inspection.

The concrete masonry in Lock 8 was commenced on May 16 and completed on May 28, 1898; in Lock 9 it was begun on June 1 and finished on June 13, 1898; in Lock 10 it was commenced on June 15 and completed on June 24, 1898; in Lock 11 it was begun on June 25 and will be finished on July 5, 1898.

STATEMENT OF THE COST OF LABOR AND MATERIAL REQUIRED TO CONSTRUCT THE WALLS OF LOCKS 8, 9, AND 10.

LOCK NO. 8 OF 8-FOOT LIFT.

Portland cement concrete	cubic yards..	1,614.8
Natural cement concrete	do....	527.3
Portland cement facing	do....	127.9
Total amount of concrete masonry	do....	2,270
Cost of concrete masonry per cubic yard		$8.11
Portland cement to 1 cubic yard of concrete	barrels..	1.30
Natural cement to 1 cubic yard of concrete	do....	1.69

Quantity and cost of labor and material.

Material:		
2,269 barrels Portland cement, at $2.10	$4,764.90	
890 barrels natural cement, at 55 cents	489.50	
1,868 tons crushed stone, at $1.50	2,802.00	
1,606 cubic yards sand and gravel, at 33 cents	529.98	
1 set hollow quoin castings	90.00	
4 curves and 2 joints 24-inch sewer pipe	14.80	
200 linear feet 30-inch sewer pipe, at $1.36	272.00	
1,680 feet B. M. oak timber in miter sills, at $27.46	46.03	
10 kegs spikes and nails, at $1.70	17.00	
23 bolts in gate wall and miter sill	12.92	
78 tons of coal, at $1.70	132.60	
1,000 gallons coal oil, at 8¼ cents per gallon	87.50	
Lumber for forming	735.47	
Cost of material		$9,993.70
Labor:		
Erecting forming	1,649.50	
Removing forming	235.00	
Erecting mixer	100.00	
Removing mixer	25.25	
Handling cement	154.95	
Handling crushed stone	375.86	
Handling gravel	309.99	
Handling sewer pipe	89.00	
Mixing concrete	308.24	
Ramming concrete	848.37	
Depositing concrete	711.53	
Mixing, depositing, and ramming facing	324.37	
Pumping lock pit and hoisting concrete	1,635.00	
Laying tracks	81.25	
Train service	264.00	
Loading and unloading material at bureau storage yard	829.27	
Loading and shipping gravel	261.25	
Superintendence at bureau and gravel pit	214.75	
Cost of labor		8,417.58
Total cost		18,411.28

LOCK NO. 9 OF 8-FOOT LIFT.

Portland cement concrete	cubic yards..	1,584.5
Natural cement concrete	do....	526
Portland cement facing	do....	74
Total amount of concrete masonry in lock	do....	2,184.5
Cost of concrete masonry per cubic yard		$7.11
Portland cement to 1 cubic yard of concrete	barrels..	1.39
Natural cement to 1 cubic yard of concrete	do....	1.70

Quantity and cost of labor and material.

Material:		
2,088 barrels Portland cement, at $2.10	$4,384.80	
905 barrels natural cement, at 55 cents	497.75	
1,858 tons crushed stone, at $1.50	2,787.00	
1,476 cubic yards sand and gravel, at 33 cents	487.08	
4 curves and 2 joints of 24-inch sewer pipe	14.80	
174 feet 30-inch sewer pipe, at $1.36	236.64	
1,680 feet B. M. oak timber in miter sills, at $27.40	46.03	
1 set hollow quoin castings	90.00	
11 kegs spikes and nails, at $1.75	19.25	
23 bolts in gate wall and miter sill	11.77	
20 tons of coal, at $1.70	34.00	
1,100 gallons coal oil, at 8½ cents	96.25	
Lumber for forming	735.47	
Cost of material		$9,450.84
Labor:		
Erecting forming	1,122.90	
Removing forming	273.21	
Erecting mixer	100.00	
Removing mixer	22.60	
Handling cement	70.12	
Handling crushed stone	406.99	
Handling gravel and sand	347.10	
Handling sewer pipe	35.00	
Mixing concrete	372.10	
Ramming concrete	714.32	
Depositing concrete	585.72	
Mixing, depositing, and ramming facing	261.48	
Hoisting concrete	301.40	
Laying tracks	71.20	
Train service	353.65	
Loading and unloading material at bureau	659.98	
Loading and shipping gravel	253.65	
Superintendence at gravel pit and bureau	135.50	
Cost of labor		6,086.92
Total cost		15,537.76

LOCK NO. 10 OF 9-FOOT LIFT.

Portland cement concrete	cubic yards..	1,726
Natural cement concrete	do....	568
Portland cement facing	do....	86
Total amount of concrete masonry	do....	2,380
Cost of concrete masonry per cubic yard		$6.58
Portland cement to 1 cubic yard of concrete	barrels..	1.21
Natural cement to 1 cubic yard of concrete	do....	1.66

Quantity and cost of labor and material.

Material:		
2,193 barrels Portland cement, at $2.10	$4,605.30	
941 barrels natural cement, at 55 cents	517.55	
1,902 tons crushed stone, at $1.50	2,853.00	
1,641 cubic yards sand and gravel, at 33 cents	541.53	
4 curves and 3 joints 24-inch sewer pipe	15.70	
200 linear feet of 30-inch sewer pipe, at $1.36	272.00	
1 set of hollow quoin castings	90.00	
1,680 feet B. M. oak timber in miter sills, at $27.40	46.03	
11 kegs spikes and nails, at $1.72	18.92	
23 bolts in gate wall and miter sill	12.92	
40 tons coal, at $1.70	68.00	
750 gallons coal oil, at 8½ cents	65.63	
Lumber for forming	735.47	
Cost of material		$9,842.05

Labor:		
Erecting forming	$1,104.20	
Removing forming	249.90	
Erecting mixer	100.00	
Removing mixer	26.30	
Handling cement	70.12	
Handling crushed stone	406.99	
Handling gravel	347.10	
Handling sewer pipe	62.00	
Mixing concrete	381.81	
Ramming concrete	672.14	
Depositing concrete	656.90	
Mixing, depositing, and ramming facing	244.80	
Pumping lock pit and hoisting concrete	383.90	
Laying tracks	75.00	
Train service	243.00	
Loading and unloading material	341.05	
Loading and shipping gravel	369.38	
Superintendence at gravel pit and bureau	123.00	
Cost of labor		$5,817.59
Total cost		15,659.6

QUANTITY AND COST OF MASONRY FOR HIGHWAY BRIDGES.

Highway Bridge No. 1, Mile 2.

299 barrels Portland cement	$859.13	
100 gallons coal oil	8.75	
30 tie bolts	34.49	
5 kegs nails	9.16	
330 cubic yards gravel	107.25	
Labor	1,017.36	
251 cubic yards concrete masonry, at $8.11		$2,036.1

Highway Bridge No. 2, Mile 5.

206 barrels Portland cement	$489.19	
101 barrels Utica cement	65.65	
30 tie bolts	34.48	
100 gallons coal oil	8.75	
2 kegs nails	4.50	
324 cubic yards gravel	97.26	
Labor	560.91	
245 cubic yards of concrete masonry, at $5.14		$1,260.7
Rubble masonry:		
38 barrels Utica cement	24.70	
1 barrel Portland cement	2.30	
134 tons stone, at $1.66	222.44	
Labor	73.00	
67 cubic yards rubble masonry, at $4.81		322.4
Total cost of masonry		1,583.1

Highway Bridge No. 3, Mile 7.

103 barrels Portland cement	$240.87	
132 barrels Utica cement	85.80	
30 tie bolts	34.48	
100 gallons coal oil	8.75	
4 kegs nails	4.10	
256 cubic yards gravel	87.04	
Labor	595.16	
186 cubic yards concrete masonry, at $5.68		$1,056.2

Rubble masonry:		
38 barrels Utica cement	$24.70	
1 barrel Portland cement	2.30	
136 tons stone, at $1.66	225.76	
Labor	55.24	
67 cubic yards rubble masonry, at $4.58		$308.00
Total cost of masonry		1,364.20

Highway Bridge No. 4, Mile 8.

294 barrels Utica cement	$191.10
322 barrels Portland cement	470.60
30 tie bolts	34.48
150 gallons coal oil	13.13
4 kegs nails	7.50
447 cubic yards gravel	160.92
Labor	855.66
355 cubic yards concrete masonry, at $4.88 (total cost of masonry).	1,733.39

Highway Bridge No. 10, Mile 16.

Approaches not yet completed.	
230.1 cubic yards Portland cement concrete in abutments, at $7.50	$1,725.75
240.8 cubic yards natural cement concrete in abutments, at $4.44	1,069.15
Cutting and boring rails for tie-rods, freight, and unloading same	77.40
Excavating foundation, 610 cubic yards, at 23 cents	140.30
Excavating foundation, 380 cubic yards, hard material, at 44½ cents	169.10
Excavating foundation, 100 pounds dynamite	10.50
Excavating foundation of wall, south approach, 416 cubic yards, at 26¾ cents	111.28
Earthwork in north approach, 800 cubic yards, at 19.4 cents	155.20
Earthwork in approach, 742 cubic yards, at 18½ cents	137.27
Rubble masonry in south approach, 493 cubic yards, at $4	2,384.15
Surveys and inspection	59.20
Total cost of work done to date	6,039.30

Work by hired labor, miles 1 to 8; grading for track and track laying by hired labor, miles 1 to 13.

Mile 1:	
16,790 cubic yards earthwork filled in around walls, approaches, etc., Lock 1	$2,115.46
Splay wall—176 cubic yards, west end Lock 1	240.55
Slope wall—	
1,724 tons stone	2,042.94
Labor laying same	1,531.86
(4,002 square yards laid, at 89 cents.)	
Total cost on mile	5,930.81
Mile 2:	
22,614 cubic yards earthwork handled on this mile, filling in and around walls of Locks 2 and 3, ditching at Lock 2, connecting south bank with Chicago, Rock Island and Pacific Railway, and excavating for abutments for Highway Bridge	3,023.47
Splay wall—	
200 cubic yards at Lock No. 2	525.75
300 cubic yards at Lock No. 3	991.42
258 cubic yards at Highway Bridge	107.13
Slope wall—	
2,333 tons of stone	2,768.16
Labor laying same	1,092.60
(6,558 square yards laid, at 59 cents.)	
Total cost on mile	8,509.03

Mile 3:	
4,817 cubic yards of earthwork handled on this mile, in excavating and embankments at arch culverts Nos. 1 and 2, building protection levee, grading railway and resurfacing embankments	$583.69
Arch culvert No. 1, 81 square yards paving laid at lower end and culvert cleaned out	175.41
Arch culvert No. 2, 84 square yards paving laid at lower end, was torn out and relaid. The discharge in culvert proper was full of muck and quicksand, which was cleaned out at total cost of	420.38
Slope wall—	
2,824 tons stone	3,346.44
Labor laying same	2,566.03
(6,558 square yards laid, at 90 cents.)	
Total cost on mile	7,091.95
Mile 4:	
18,147 cubic yards earthwork handled on this mile in filling in around the walls of Lock 4, building a protection levee at Lock 4, building approach at west end of Aqueduct No. 1, grading track and removing cross banks, ditching, etc	2,924.89
Slope wall—	
2,700 tons stone	3,199.50
Labor laying same	2,112.78
(6,354 square yards laid, at 82 cents, along new creek channel to protect new bank and along inside of canal embankment.)	
Splay wall—263 cubic yards has been laid at aqueduct No. 1 and at Lock No. 4	502.85
About 76,500 cubic yards of material was stripped from the Carlson gravel pit on this mile, 12,000 of which was used in building up canal embankments and building up lock acre at Lock 4, at a total cost of	9,789.68
Total cost of work done on this mile	18,429.70
Mile 5:	
17,959 cubic yards of earthwork has been handled on this mile in excavating for bridge abutments and building approaches to same, filling over slope wall, and in excavating bend of creek to prevent damage to canal embankment	2,931.66
Slope wall, bank revetment—	
1,833 tons stone	2,172.10
Labor laying same	1,760.21
(4,256 square yards laid at 92 cents.)	
Splay wall—258 cubic yards laid at highway bridge	109.10
Total cost on this mile	6,973.07
Mile 6:	
1,263 cubic yards of earthwork has been handled on this mile in filling over slope walls	149.25
Slope wall, bank revetment—	
2,280 tons stone	2,701.80
Labor laying same	1,839.44
(5,288 square yards laid at 86 cents.)	
Arch culvert No. 3—Cleaning out and repaving discharge	233.56
Total cost on this mile	4,924.05
Mile 7:	
22,819 cubic yards of earthwork has been handled on this mile in removing cross banks, enlarging basin near arch culvert No. 4, filling in around walls of Lock No. 6, surfacing track, and excavating for abutments for highway bridge and building approaches to same	2,666.17
Slope wall, bank revetment—	
585 tons stone	693.22
Labor laying same	821.78
(1,992 square yards laid at 76 cents.)	
Arch culvert No. 4—This culvert which had filled with a deposit of quicksand, etc., was cleaned out and discharge of same repaved	406.85
Splay wall.—434 cubic yards laid at Lock No. 6, and at highway bridge	434.30
Total cost on this mile	5,022.32

Mile 8:	
25,805 cubic yards of earthwork handled on this mile, in excavating for abutments for highway bridge and building approaches to same, removing cross bank at Lock No. 7, excavating for new creek channel, filling in around walls of Lock No. 7, and filling over arch culverts No. 5	$6,440.94
Slope wall, bank revetment.—1,115 tons stone	1,321.28
Labor, including distribution of stone to complete mile, and laying 728 square yards slope wall	1,431.30
Splay wall.—608 cubic yards laid at Lock No. 7, and at highway bridge	866.28
(The earthwork at Lock No 7 and also approaches to highway bridge on this mile was done at great disadvantage on account of the extra-long haul, about 1,200 feet.)	
Total cost on this mile	10,059.80
Mile 9:	
2,904 cubic yards of earthwork has been graded for track at Locks 8 and 9	261.35
860 tons of stone	1,019.10
Slope wall, bank revetment—Labor, including distribution of stone to complete mile and laying 1,995 square yards slope wall	1,040.34
Total cost of mile	2,320.79

MISCELLANEOUS WORK ON MILES 1 TO 9, UNDER INSPECTOR J. D. TRUSS, JR.

Weeds were cut from canal embankments, miles 1 to 7; willows planted where necessary to protect canal embankments; built temporary highway bridge, miles 2 and 5; a farm bridge on mile 7; and a railway bridge on mile 12, 352 feet long	$433.95
The train service force loading material at Bureau and Lock 6 yards, operating, pumping, hoisting, and mixing engines, for the following structures:	
Lock No. 8	2,641.60
Lock No. 9	1,649.05
Lock No. 10	2,110.83
Lock No. 11	1,483.97
Lock No. 12	392.11
Total	8,711.51

In addition to the above work, all of the piling, timbers, drain tile, etc., stored in the Y yard at bureau was removed to the Lock 6 yard, the track torn out and fence rebuilt along right of way.

The Bureau storage yard was cleared up preparatory to receiving material. The foundation of large warehouse was repaired by replacing 71 new blocks. The locomotives "Hennepin" and "Davenport" were dismantled and shipped to Pittsburg, Pa., for repairs; were returned and set up and placed in service.

A locomotive shed 28 feet by 40 feet, with three engine pits and a blacksmith and car repair shop, 14 by 24 feet, were erected at Lock No. 6.

The locomotive supply tank at Lock No. 4 was shipped to Lock 12. A new one was set up at Lock No. 6 and all of the tools, cars, and machinery of all kinds have been kept in repair.

5.7 miles of additional narrow-guage railway track has been laid along canal tow path for permanent use, 11.7 miles of such track has been maintained and 3.5 miles of temporary track built, at a total cost of	$8,147.32
8.9 miles of temporary track was torn up and removed after use, costing	1,455.95
Total cost	9,603.27

TELEPHONE LINE.

A telephone line has been constructed along the line of canal from the Bureau storage yard to the inspector's office on mile 24, a distance of 21 miles. Instruments were put in at Bureau storage yard, gravel pit, Lock 6, assistant engineer's office at Tiskilwa, inspector's office at Lock 11, *at lock under construction*, inspector's office

at Lock 13, inspector's office at Lock 19, inspector's office at mile 24, nine instruments in all. Cost of line as follows:

Labor	$338.03
Material	411.17
Instruments	143.00
Total cost of line	892.20

MISCELLANEOUS HIRED LABOR ON MILES 9, 10, AND 11, UNDER INSPECTOR S. L. BAYLESS.

Other than that engaged in the construction of locks, hired labor was employed as follows:

Clearing out seep ditches, building a protection levee to prevent high water from overflowing the canal at the east end of Lock 8, covering drain tile on Lock 9, constructing a protection levee on east side of lower Princeton road, grading a wagon road from public highway to Lock 9, building two protection levees opposite Slip Point and one at the west end of Lock 10, planting willows at the foot of slope paving on miles 10 and 11, delivering gravel at Lock 10, placing culvert pipes under upper Princeton road crossing, grading ground about superintendent's house at Lock 11, rebuilding and repairing right-of-way fence on miles 9, 10, and 11, and removing driftwood and other obstructions in the new creek channel on mile 11.

MISCELLANEOUS HIRED LABOR ON MILES 12 TO 16, UNDER INSPECTOR C. A. BROWNE.

Hired labor was engaged as follows:

1,858 cubic yards of gravel has been delivered at Lock 12 for concrete work, at a cost of	$483.82
On mile 13 three rows of willows, extending 1,400 linear feet, requiring 2,100 willows, have been planted as a fence protection, costing	15.23
On mile 14, at the head of arch culvert No. 7, 400 willows were planted as a protection to the sides of the channel, costing	2.63
On mile 16 the hardpan slopes of cuts have been soiled and seeded; 1,110 cubic yards of material was required for this work, at a cost of	154.48
It was necessary to terrace these slopes (about 3,000 square yards), and the material had to be moved with pick and shovel, it being too hard to plow, at a cost of	84.53
The fills on the new highway on mile 16 have been widened and the slopes soiled and seeded; 920 cubic yards of material was required for this work, at a cost of	183.43
1,000 feet of fence, 3 boards high, has been erected along the sides of these fills, at a cost of	44.27
10,440 cubic yards of grading has been done on miles 12, 13, 14, and 15, for the construction of the narrow-gauge railroad and for switches of the Chicago, Rock Island and Pacific Railway, at Locks No. 13 and No. 17, at a cost of	1,627.16

This work embraced the approaches of both ends of the bridge over main Bureau Creek, on mile 12, and the side track for handling cement, forming, and stone at Locks 12, 13, and 14.

About 4,000 feet of standard side tracks have been laid at Locks 13 and 17, at a total cost of	230.91

The side track at Lock 13 is designed to receive the material for Locks 12 and 13, and the one at Lock 17 is designed to extend to Lock 14, and the material received on the Chicago, Rock Island and Pacific Railway will be delivered to Locks 14, 15, 16, and 17 without transfer.

DWELLINGS.

Superintendent's house at Lock 3.—This is a two-story house containing six rooms, and was built by hired labor, at a cost of $1,916.51.

Lock-keeper's house at Lock No. 6.—This is a one-story house containing four rooms, and was built by hired labor, at a cost of $1,100.40.

Superintendent's house at Lock No. 11.—This is a two-story house containing seven rooms, and was built by hired labor, at a cost of $1,555.30.

Lock-keeper's house at Lock No. 13.—This is an old two-story house of seven rooms, that was on the right of way when the land was acquired by the United States. It was moved to a new site by contract under ten-day proposals, and repaired by hired labor, at a total cost of $599.70.

Superintendent's house at Lock No. 19.—This is a two-story house of six rooms, and built by hired labor, at a cost of $1,689.70.

House for inspector's office on mile 24.—This is a one-story house containing four rooms, and was built by hired labor, at a cost of $637.24.

FENCING RIGHT OF WAY.

A 6-strand barbed-wire fence was constructed to inclose the canal right of way from miles 17 to 24 inclusive. The material was purchased under ten-day proposals, and the labor was done under a contract let to E. W. Eddy, of Wyanet, Ill., under ten-day proposals. The cost was as follows:

Mile 17:		
Material	$126.91	
Labor	52.35	
Total cost on this mile		$179.26
Mile 18:		
Material	179.41	
Labor	72.94	
Total		252.35
Mile 19:		
Material	169.90	
Labor	68.40	
Total		238.30
Mile 20:		
Material	159.86	
Labor	69.20	
Total		229.06
Mile 21:		
Material	136.14	
Labor	58.74	
Total		194.88
Mile 22:		
Material	111.00	
Labor	47.93	
Total		158.93
Mile 23:		
Material	155.78	
Labor	67.19	
Total		222.97
Mile 24:		
Material	173.30	
Labor	73.64	
Total		246.94
Total cost of 14.6 miles, at $117.99		1,722.69

SURVEYS, ETC., MADE BY INSPECTOR J. W. WOERMANN, MILES 20 TO 24 INCLUSIVE.

The right of way was staked out on all 5 miles. The earthwork was staked out on the whole of miles 20 and 21, on 3,000 feet of mile 22, and on 1,500 feet of mile 24. The level notes for same were reduced and the cross sections platted. The erection of the fencing was inspected and measured.

Six new bench marks were established.

The watersheds to be drained through the culverts, as originally proposed at Stations 1243, 1335, and 1410, were located in the field; also the buildings and adjoining fences of John L. Smith, section 1, Mineral Township.

A map was prepared showing the watersheds to be drained through the culverts, as then proposed at Stations 1243, 1335, and 1410, the acreage computed, and the size of culverts computed. A comparative estimate was made of two different drainage projects on miles 24 and 25. Four blue prints of the right of way from mile 24

to 27.8 were made and colored for court purposes. Five extra sets of agreements were written for right of way from mile 24 to 27.8.

Assisted in preparing 18 sets of agreements. The ownership of existing ditches, and rights of tenants and others having interests in the tracts on that section, were determined and prices secured. The amount of excavation and embankment, including seep ditches and bridge approaches from mile 24 to 27.8, was computed and a summary prepared, showing the total amount of earthwork in each class for each mile.

The data in regard to the cost of the various classes of work on the eastern section was summarized and tabulated.

CEMENT TESTS.

Two hundred and nine cars of cement have been inspected, as follows:

	Carloads.
For the United States:	
Alpha Portland	30
Atlas Portland	42
Saylor's Portland	8
Utica, natural	31
For contractors:	
Atlas Portland	16
Empire Portland	1
Utica, natural	81

Representing about 26,500 barrels of cement.

During the year about 6,000 briquets were made, of which 4,860 have been broken for tensile strength, leaving on hand about 1,140 briquets unbroken.

Ninety-one long time tests, extending over periods of seven days, twenty-eight days, three, six, nine, and twelve months, and two years, were made, on which briquets have been broken, as follows:

ATLAS PORTLAND, AVERAGE OF 38 BRIQUETS.

	7 days.	28 days.	3 months.
Neat	520	608	651
1 part cement to 3 parts sand	152	222	317

SAYLOR'S PORTLAND, AVERAGE OF 19 BRIQUETS.

Neat	574	660	743
1 part cement to 3 parts sand	127	194	262

UTICA, NATURAL, AVERAGE OF 17 BRIQUETS.

Neat	182	211	260
1 part cement to 1 part sand	117	223	289

Cars Nos. 7716 and 6246 of Saylor's Portland cement were found to be below specifications for tensile strength, and a number of tests and recheck tests were made, several of which are given below:

Six months' tests, car No. 7716, Saylor's Portland cement.

[Average of 8 briquets.]

	7 days.	28 days.	3 months.	6 months.
Neat	583	590	604	577
1 part cement to 3 parts sand	89	138	200	224

Samples of cement were taken from this carload and exposed to the air in a shallow pan for ten days, and turned with trowel once each day during that time. Seven

and twenty-eight day tests were made for tensile strength, showing the following result from an average of nine briquets.

	7 days.	28 days.
Neat	567	609
1 part cement to 3 parts sand	86	124

These briquets show slightly lower tensile strength than those made in the usual way.

Air tests, Saylor's Portland cement.

1 part cement to 3 parts sand, briquets kept 1 day in air, 6 days in water, and balance of time in air:

1 month	200
2 months	202
3 months	198

1 part cement to 3 parts sand, briquets 1 day in air, 29 days in water, and balance of time in air:

2 months	237
3 months	225

Car No. 6246, Saylor's Portland cement, was put through the same tests and showed slightly higher tensile strength than car No. 7716.

The following tests of Atlas Portland and Utica Natural cements were made with increased proportions of sand:

	7 days.	28 days.
Atlas, 1 part cement to 4 sand	101	156
Atlas, 1 part cement to 5 sand	62	113
Utica, 1 part cement to 2 sand	51	83
Utica, 1 part cement to 3 sand	33	55
Utica, 1 part cement to 4 sand	28	50

Various tests have been made on samples of sand and gravel.

WORK DONE BY DRAFTSMAN.

Made an approximate estimate of excavation and embankments, miles 16 to 24, inclusive, and also tabular statement of same; made a plat of canal showing right of way from Station 785 to 826, to show a proposed location of Lock No. 18, with approaches and embankments; made a drawing showing topography and proposed structures and embankments from mile 16 to mile 20; a tracing of same was also made; made a drawing and tracing showing change of location of Lock No. 19; made a map and tracing showing relocation of Lock No. 6, and the Chicago, Rock Island and Pacific Railway, and canal embankments in the vicinity of the lock; made profile of north and south right of way of Chicago, Rock Island and Pacific Railway, also the center line of canal in the vicinity of Lock No. 6; made a plat and tracing showing right of way, with alternate locations of Lock No. 19 and approaches, and the proposed crossing of public highway on mile 16. Cross sections were platted of ground between Stations 835 and 861, with lock pits and proposed road, for calculating earthwork. Platted a profile, mile 20 to mile 24, in 1-mile sections, showing borings taken at ¼-mile intervals, with proposed structures and grades of embankments, and made tracing of same. Made tracings and blue prints of two different plans of slope paving. Revised the sheets showing location of embankments and excavations, miles 16 to 20 and miles 20 to 24. Profiles on large scale in 1-mile sections on sheets of 4 miles, showing borings taken at ¼-mile intervals, were platted, and tracings made of miles 16 to 20 and 20 to 24. Drawings and tracings showing borings at sites of Locks Nos. 19, 20, and 21 were made. The field profiles and copies of cross-section notes were made of the different sections for use of inspectors in the field. The right of way from mile 24 to 27.8 was platted on a scale of 1 inch equaling 200 feet, and the separate tracts traversed by line of survey calculated and subplats of each tract, with tracings and blue prints with descriptions and backings in triplicate made preparatory to court proceedings in Chicago, Ill.

Agreements between the United States and landowners were prepared and signed by owners. A drawing on a scale of 1 inch to 600 feet, from mile 24 to mile 27.8, showing topography and proposed structures, with profile and grades, was completed, and a tracing of same was made; a drawing on a scale of 1 inch to 600 feet, from mile 24 to mile 27.8, showing right of way required from different landowners, with the size, shape, and location of the separate tracts, with reference notes of abstracts, plat numbers, and all data that could be procured, and size of each farm and acreage, as left on each side of canal, and tracing of same made. Abstracts of title were procured of land traversed by canal, mile 24 to mile 27.8, and owners of same established. A plat, No. 46 B. of extra land required for right of way purposes and tracing and descriptions were written in triplicate. A profile and tracing showing proposed location of public road near Pond Creek Station was made. A tracing was made of general arrangement of splay walls for arch culverts; made a sketch showing proposed location of new channel of Bureau Creek, near Aqueduct No. 2. Progress sketches of locks and aqueducts, earthwork, and arch and pipe culverts were made up monthly from August, 1897, to February, 1898, for files in this office. An extra plat, No. 115 A, with description, was made in triplicate. Estimates for drainage ditches on the north side of canal from Station 1245 to Station 1347 and on the south side from Station 1323 to Station 1416 were made. A drawing was prepared to show project of drainage, mile 24 to 27.8; made topographical map of the vicinity of Pond Creek, showing work completed to date. A system for indexing notebooks has been made. New form for cement-tests record were ruled. A drawing showing topography and all structures as finally located, with profile showing grades, etc., mile 0 to 4, has been completed and tracing made. A drawing showing topography and all structures as finally located, with profiles, etc., miles 4 to 8, is about 75 per cent complete; sketched additional topography for these maps in the field. A drawing and tracing were made, showing topography in the vicinity of Lock No. 8, to determine drainage. A tracing was made showing design for concrete mixer; made estimate for fencing miles 16 to 24, inclusive, and assisted in sundry clerical office work. About 350 blue prints were made.

EMPLOYEES.

The work let to contract and that done by hired labor has been distributed along the canal from miles 1 to 24 and has been divided into divisions, with the following-named inspectors in charge: J. D. Truss, jr., S. L. Bayless, Charles A. Browne, A. O. Rowse, and J. W. Woermann. These gentlemen have been assisted by the following-named subinspectors: Charles E. Sheriff, Oscar E. Strehlow, Henry Fox, W. H. Ferguson, H. J. Emmons, J. G. Palmer, George P. Hawley, Clarence A. Clement, and H. C. Estee.

The clerical department has been under C. F. Scott, as clerk, assisted by H. D. Corbett and Elmer V. Williams, as receivers of material. George W. Choate has been in charge of inspection of cement, assisted by Willis Hunter as cement tester. Miss Anna Whiting has been employed as typewriter and Thomas H. Joy as draftsman, all of whom I am indebted to for faithful and intelligent assistance.

I have the honor to be, your obedient servant,

JAS. C. LONG,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

REPORT OF MR. L. L. WHEELER, ASSISTANT ENGINEER.

STERLING, ILL., *June 30, 1898.*

MAJOR: I have the honor to submit the following report on the work done on the Illinois and Mississippi Canal under my supervision during the fiscal year ending June 30, 1898:

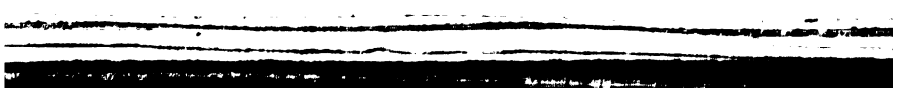
FEEDER.

Ten additional pieces of land required for highway purposes were described, and agreements entered into with the owners for the purchase of them. Site maps were made of the sites of all highway and railway crossings, and of culverts and aqueducts. A large amount of work was done in connection with securing right of way by process of condemnation, which will be more fully described in connection with similar work on the main line.

WESTERN SECTION, MAIN LINE.

At the date of last annual report the field work of describing lands required for right of way for the western section had been completed. The notes were reduced,

LOCK 5.



was computed, descriptions written, plats and maps made, title abstracts prepared and agreements drawn up for the 34 miles of right of way for the main line, included between the feeder junction and Rock River. In all, 129 tracts of land are included in that portion of the right of way, and as all papers, except title abstracts, were prepared in triplicate, their preparation involved an enormous amount of careful labor.

The method of locating and describing the lands was as follows: The center line was first staked out, all the curves being run in and the position of the center line marked at the fence lines and other places where cultivation could not disturb the marks, usually by oak hubs, but in special cases by iron rails driven into the ground.

The right of way ordinarily is 300 feet wide, and the boundaries are marked on the ground by 30 pound iron rails, 3½ feet long, driven about 3 feet into the ground. These iron rails are located ordinarily at the intersection of the boundaries, with the boundaries between farms, and in every case are placed once in each half mile. The measurements are then taken to enable the area of each tract to be computed and description written. The measurements and descriptions proceed around the tract in the opposite direction to the movement of the hands of a watch. The areas are computed by methods of latitudes and departures and carefully checked.

Each description consists of three parts: First, the point of origin of measurements is described with reference to some known point in the public land survey. Second, the courses and distances around the tract are given. Third, the area is given and a statement given of the land subdivision in which the tract lies.

All courses are given with reference to the true meridian, and for the purpose of determining true meridian, observations were made at frequent intervals upon Polaris. A plat of each tract was made on the scale of 1 inch equals 200 feet, on which was shown all the courses, distances, section, township, and county in which the land was situated, the name of the owner and the contents of the tract. These plats were made of a uniform width to correspond with the paper on which the descriptions were written.

Three copies of the descriptions were typewritten, and to each copy was attached a blue print of the plat. A brief was placed upon the descriptions, which showed the number of the description, the number of the title abstract, the township, range, section, and county, the owner's name, and post-office address. One copy of these plats and descriptions was sent to an abstracter of titles, who prepared a title abstract covering the land required. Agreements in triplicate were then prepared which set up the laws under which right of way for the canal is being acquired, which contained a description of the land in question, and a provision for the sale to the United States of the lands described for a certain sum. A copy of the plat was attached to each agreement. The owners were then notified that a part of their land would be required for canal purposes and the agreements left with them with the request that they state a price for which they would sell the land required. Where the price was named by the property owner I prepared a certificate certifying to the value of the land in question, and the damages resulting to the remainder of the premises, and recommended the acceptance or rejection of the proposal according as I deemed the price reasonable or unreasonable. After the papers had reached this stage two copies of the plats and descriptions and accompanying maps, two copies of the agreements and the abstracts of title were forwarded to you. I submit herewith a sample of the descriptions, a sample page from the title abstract, and a sample of the certificate supplied by the abstracters.

Earthwork in excavation and embankment, in bridge approaches and in seepage and intersecting ditches was computed and tabulated by miles. Site maps were made of all highway and railway crossings and maps traced.

Prior to this fiscal year there had been obtained for right of way near Milan in the western section of the main line 134.43 acres of land at a cost of $11,697.70, and on the eastern section of the main line 972.44 acres at a cost of $107,559.91.

At the December term of the United States district court for the northern district of Illinois the district attorney filed a petition for the condemnation of the lands in the first 24½ miles of the feeder for the purchase of which no satisfactory agreements had been made with the landowners. This case came to trial in January, but before coming to trial satisfactory settlements had been reached with all the property owners except two. Special surveys and maps were made of the property in dispute and considerable time of this office force was taken in preparation of the necessary data for the trial and in attendance at the trial. The proceedings in the case were concluded and 257.49 acres obtained at a cost of $28,931.55, giving a total amount of right of way obtained up to that time of 1,364.36 acres at a cost of $148,189.16.

One of the contestants in this case claimed ownership in the bed of Rock River and demanded $10,000 for damages which he claimed he would suffer by reason of the increased depth of water. The court decided that if the stream was a navigable one ownership would terminate at the margin of the stream, and the question as to whether or not Rock River was a navigable stream was submitted to the jury as a

question of fact. After hearing the evidence in the case, the jury returned the following verdict:

"We, the jury, find that Rock River is a navigable waterway of the United States up to and beyond the land of the defendant, Maxson."

The land of the defendant, Maxson, is situated near the eastern limits of the city of Sterling, Ill.

A large number of satisfactory propositions had been received from landowners for lands required for the feeder, for the western section, east of Geneseo, for the eastern section from Mile 24 to the feeder junction, and also for lands along Rock River, east of Sterling, to be overflowed. On account of many imperfections in title and of parties having liens upon the lands as mortgagees or tenants, it has been considered necessary to acquire title through the process of condemnation, even if a satisfactory agreement had been reached with the owner of the fee.

On account of the large amount of legal work to be done in connection with securing right of way for the canal, the Attorney-General appointed Mr. Charles A. Atkinson as special attorney to do this work. Mr. Atkinson arrived at this office February 23, and the work of preparing a petition to be presented to the May term of the district court commenced. The petition was filed March 26, and the case was put on trial May 2. In all 155 parcels of land were included in the proceedings and 520 parties made defendants. Settlements were made for all but one parcel, and this was contested.

The preparation of the petition, the verdict of the jury, and the decree of the court was done in this office, and involved an enormous amount of work. Notices for publication were prepared and inserted in newspapers published in the three counties in which the lands were situated. Slips containing notices were mailed to nonresident defendants. Four lists of names of defendants with their addresses, where known, were furnished the United States marshal to assist him in serving summonses. Finally a copy of the petition, verdict, decree, and list of names was furnished the United States district court for a certified copy of the proceedings. An opinion was prepared for the Attorney-General in the case, and the proceedings received his approval.

Under the proceedings in this case, title was acquired in 1,616.61 acres at a cost of $161,204.59, making the total amount of right of way secured as this date 2,980.97 acres at a cost of $309,393.75.

The amount of land remaining to be acquired for right-of-way purposes and for flowage is as follows:

	Acres.
On eastern section	73.56
On western section	898.28
On feeder	30.39
Overflow lands	1,129.67
Total	2,131.90

Accompanying this report are two maps, one showing lands already acquired and those to be acquired for right-of-way purposes, the other showing overflow lands acquired and those yet to be acquired.

At the beginning of the fiscal year fifteen employees were on the rolls of this office, all employed in the preparation of data relating to right of way. The force has been gradually decreased, by transfer and dismissal, as the work required, until at the close of the year the employees consist of Mr. J. B. Bassett, Mr. Fred W. Honens, Mr. F. B. Duis, and Miss G. A. Deyoe. My thanks are due all the employees for the faithfulness and care with which they have performed their duties. I desire to make special mention of the accuracy and care with which Miss Deyoe has typewritten the large number of land descriptions and legal papers.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

SAMPLE DESCRIPTION.

DESCRIPTION NO. 107.

Beginning at a point on half-section line south eighty-nine degrees east (S. 89° 00′ E.) three hundred and seven and three-tenths (307.3) feet from the center of section thirty-four (34) in township seventeen (17) north and range six (6) east of the fourth principal meridian, in Bureau County and State of Illinois.

Thence south eighty-nine degrees east (S. 89° 00′ E.) three hundred and fifty-two (352) feet; thence north thirty degrees and thirty-one minutes west (N. 30° 31′ W.)

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six hundred and thirteen and two-tenths (613.2) feet; thence following curve to the right with radius of twenty-seven hundred and fifteen (2715) feet for a distance of eight hundred and thirty-six and five-tenths (836.5) feet, the chord of said curve running north twenty-one degrees and forty-one minutes west (N. 21° 41′ W.); thence south eighty-nine degrees and twenty minutes west (S. 89° 20′ W.) three hundred and thirty-two and four-tenths (332.4) feet; thence south twelve degrees and thirty-six minutes east (S. 12° 36′ E.) one hundred and fourteen and nine-tenths (114.9) feet; thence north seventy-six degrees and nineteen minutes east (N. 76° 19′ E.) twenty-five (25) feet; thence following curve to the left with radius of three thousand and fifteen (3,015) feet for a distance of eight hundred and eighty-five and three-tenths (885.3) feet, the chord of said curve running south twenty-two degrees and six minutes east (S. 22° 06′ E.); thence south thirty degrees and thirty-one minutes east (S. 30° 31′ E.) four hundred and twenty-nine and one-tenth (429.1) feet to point of beginning.

Containing nine and ninety-eight hundredths (9.98) acres, more or less, and being a part of the southeast quarter (SE. ¼) of the northwest quarter (NW. ¼) and the southwest quarter (SW. ¼) of the northeast quarter (NE. ¼) of section thirty-four (34) in said township.

All bearings given above are referred to true meridian.

SAMPLE PAGE OF ABSTRACT.

Swamp Land.
Illinois Session Laws,
1852, page 178.

(3) State of Illinois
to
Bureau County, Illinois.

Grants: SW. ¼ NE. ¼ Sec. 34, Tp. 17 N., R. 6 E.; 40 acres.

Swamp Land.
Book 44, page 580.
Dated Jan. 9, 1865.
Filed Feb. 12, 1866.

(4) Bureau County, by S. G. Paddock, clerk,
to
Louis Schlote, assignee of David Marple.

$220. NE. ¼ Sec. 34, Tp. 17 N., R. 6 east.

Warranty Deed.
Book 57, page 147.
Dated Sept. 26, 1870.
Filed Oct. 10, 1870.

(5) Lewis Schlote and Moriah Ursula, his wife,
to
Frederick Rieder.

$950. SW. ¼ NE. ¼ Sec. 34, Tp. 17 N., R. 6 E.; 40 acres, more or less. Acknowledged before William Wilson, N. P., Bureau County, Illinois, Sept. 26, 1870.

Mortgage.
Book X, page 290.
Dated Sept. 26, 1870.
Filed Oct. 3, 1870.

(6) Frederick Rieder and Margaret, his wife,
to
W. C. and William C. Boyden.

$600. SW. ¼ NE. ¼ Sec. 34, Tp. 17 N., R. 6 E. Due 2 years, 10%. Acknowledged before L. M. Norton, J. P., Bureau County, Illinois, Sept. 26, 1870.

SAMPLE CERTIFICATE FURNISHED BY ABSTRACTER.

STATE OF ILLINOIS,
Bureau County, ss:

I, F. W. Stewart, abstracter of real estate titles in said county, do hereby certify that I have made a careful examination of the land and court records of said county, and that the foregoing examination of title, consisting of twelve (12) numbers, numbered from 1 to 12, inclusive, contains all the conveyances of the premises described in the heading hereof, and all judgments, liens, causes in action, or other matters of record affecting the title of said premises. Further, that all instruments shown herein are in due form and properly executed, unless duly noted herein to the contrary.

That there are no tax liens upon said premises; that, in my opinion and belief, Frederick Rieder is the legal and equitable owner of said premises, subject to mortgage at No. 12, herein.

Dated at Princeton, Illinois, this the twenty-second (22) day of July, A. D. 1896, at 10.00 o'clock a. m.

(Signed) F. W. STEWART.

J J 8.

OPERATING AND CARE OF ILLINOIS AND MISSISSIPPI CANAL; CA AROUND LOWER RAPIDS OF ROCK RIVER AT MILAN, ILL.

This canal is 4½ miles in length, surmounting a fall of 18 feet, the works operated and cared for include 3 locks, 3 swing bridg sluiceways, 1 arch culvert, 3 lock houses, 1 office building, and 2 d

The canal was formally opened to navigation April 17, 1895.

On account of three fixed bridges across Rock River a few n above the head of the canal, its traffic is restricted to excursion and to barges and to such small steam craft as may pass under bridges.

Proceedings were instituted to compel the city of Moline to alte bridge, but the authority of the Secretary of War was denied by city of Moline. The United States district court for the northern trict of Illinois, in a preliminary ruling, sustained the United St authority, and later a jury in the trial of the condemnation cas United States *v.* Maxson brought in a special verdict finding I River to be a navigable water of the United States up to and past upper rapids of Rock River at Sterling, Ill. The contention apparently been closed by the sundry civil act of July 1, 1898, w allots $25,000 for the construction of a high bridge for the city of M in lieu of the existing bridge complained of.

The canal and its accessory works have been operated and m tained in good order during the past year. The main support sluice gates were protected by movable roofs; repairs were mad roads, lock houses, and dams; 2,650 cubic yards material at mout canal was removed by dredging, and willows planted along parts o canal banks for their protection.

During the season of navigation boats and barges aggrega 94,609 tons passed the canal, carrying 20,430 tons of coal and 2 passengers.

The use of the canal is restricted by the obstructive bridges ac Rock River above it, but the coal by canal controls the price of this n sary article at Davenport and vicinity, and this result has been in e ever since the opening of the canal. A reduction of from 3 to 5 c a bushel, or say $1 per ton, on all soft coal used has resulted, which already justified the construction of this part of the canal as an i pendent work. The change in the Moline bridge will make this c an important line of transportation.

There was expended during the year ending June 30, 1898, $4,50 exclusive of $366.64 outstanding liabilities.

Money statement.

July 1, 1897, balance unexpended (outstanding)	$8
July 1, 1897, allotment for fiscal year	6,5
Total	7,3
June 30, 1898, amount expended during fiscal year	4,5
July 1, 1898, balance unexpended	2,8
July 1, 1898, outstanding liabilities	3
July 1, 1898, balance available	2,5

Disbursements, fiscal year 1898.

Operating and caring for locks and bridges	$3,772.16
Dredging at entrance to lower lock	717.48
Property	12.75
	4,502.39

Itemized statement of expenses made from appropriation for operating and care of canals and other works of navigation, indefinite, applied to western section Illinois and Mississippi Canal.

Date.	No. of voucher.	To whom paid.	For what paid.	Amount.
1897.				
July 1	1	Hired men	Services	$310.87
15	2	Delaska South	Team hire	10.00
15	3	Crerar, Adams & Co	Hardware	3.50
15	4	Builders' Sand and Gravel Co	Dredging at lock 37	452.48
15	5	Dimock, Gould & Co	Lumber	37.15
15	6	C. H. Dibbern & Son	Oil, etc	27.61
31	7	Hired men	Services	269.18
Aug. 13	1	Delaska South	Hire of horse and buggy	5.00
13	2	Martin H. Kendig	Lockage blanks	12.80
Sept. 1	1	Hired men	Services	292.10
15	2	Lindsay & Phelps Co	Lumber	6.81
15	3	Henry Dart's Sons	Oil	4.70
15	4	Delaska South	Hire of horse and buggy	8.00
15	5	L. L. Wheeler	Traveling expenses	16.21
15	6	Vulcan Iron Works	Boat spikes	11.10
Oct. 5	1	Hired men	Services	266.20
5	2	L. L. Wheeler	Traveling expenses	10.82
5	3	Delaska South	Hire of horse and buggy	4.00
15	4	E. H. Warner	Lumber	77.28
Nov. 2	1	Hired men	Services	263.40
5	2	Cyrus M. Michael	Hauling rock	42.12
5	3	Delaska South	Hire of horse and buggy	7.00
5	4	Blatchford Cartridge Works	Cartridges	12.00
5	5	Thayer & Jackson Stationery Co	Job printing	15.00
30	6	Hired men	Services	259.20
Dec. 7	1	Delaska South	Livery hire	5.00
7	2	Henry Dart's Sons	Oil	4.75
7	3	C. H. Dibbern & Son	Screws, staples, etc	3.10
31	4	Hired men	Services	210.00
1898.				
Feb. 1	1	do	do	210.00
Mar. 2	2	do	do	210.00
Apr. 7	1	do	do	225.00
20	2	Delaska South	Livery hire	3.00
May 2	1	Hired men	Services	274.10
7	2	Delaska South	Livery hire	4.00
19	3	H. L. Franing	Wall paper	37.65
25	4	John H. Gilmore	Flour and glue	2.45
25	5	J. W. Stewart	Waste, paint, etc	38.50
25	6	The Trapp Darling Co	Dredging	265.00
31	7	Hired men	Services	266.51
June 9	1	L. L. Wheeler	Traveling expenses	52.90
9	2	Delaska South	Hire of horse and buggy	4.00
9	3	John Volk & Co	Picture molding	2.00
25	4	Henry Dart's Sons	Oil	5.40
30	5	Hired men	Services	255.00
		Total		4,502.39

REPORT OF MR. L. L. WHEELER, ASSISTANT ENGINEER.

STERLING, ILL., *June 30, 1898.*

MAJOR: I have the honor to submit the following report on the operating and care of canal around Lower Rapids of Rock River during the fiscal year ending June 30, 1898.

The canal was closed to navigation November 30 and opened again March 21. No serious accident occurred in the operation of the canal during the year, and the condition of the banks and structures is practically the same as at the date of last

report. The levels were maintained during the winter and permits were sold for cutting ice from the canal, and the proceeds, $116, transmitted to Chicago.

Movable roofs for main support of four sluice gates at Mill Creek were constructed and painted. The roof of bridge tender's house was painted. Nine rooms in lock and bridge tenders' houses were papered. One hundred and eight cubic yards of broken stone were hauled from the guard lock and put on the road in third mile.

The areas below the dams were sounded in August, 1897, and the soundings platted. They showed that practically no erosion had taken place below the north dam, but that below the south dam, where it was founded on gravel, considerable erosion had taken place. It was not considered enough, however, to in any way endanger the dam. The pine cross timbers, which are at the level of the apron of the dams and form part of it, were largely cut away by ice falling over the crest. These pine timbers were cut out and replaced by oak pieces.

During the winter and spring sand was deposited by the river at the entrance to Lock 37. Proposals were prepared inviting bids for removing this sand and the contract let to the Tropp-Darling Company, of Rock Island, at 10 cents per cubic yard, scow measurement. They removed 2,650 cubic yards of sand by means of a sand pump, which gave a good depth at the entrance.

The willow settings which were planted in the spring of 1897 as an experiment in protecting embankments against wave wash nearly all lived and are thriving.

Regulations for the use, administration, and navigation of the canal were prepared, printed, and distributed to the proper persons. The commerce through the canal is almost entirely confined to the transportation of coal from the mines along Rock River to the cities on the Mississippi. The coal trade has materially increased since last report, but on account of low water in the upper tributaries of the Mississippi River the demand for coal so far this season has been light. The Moline wagon bridge still continues to obstruct navigation.

Herewith is a table showing commerce through the canal since April 17, 1895, the date when it was opened to navigation.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

Maj. W. L. MARSHALL,
Corps of Engineers, U. S. A.

Traffic on the western section Illinois and Mississippi Canal since April 17, 1895.

	Year ending June 30—			
	1895.	1896.	1897.	1898.
Steamboats.....number..	24	150	389	523
Barges.....do....	9	115	331	499
Steamboats.....tons..	858	4,065	10,037	17,800
Barges.....do....	679	14,255	46,584	76,809
Lockages.....number..	186	562	1,531	2,175
Passengers.....do....	3,539	3,634	1,151	2,279
Freight.....tons..	6	1,865	9,583	20,430

APPENDIX K K.

IMPROVEMENT OF MICHIGAN CITY HARBOR, INDIANA, AND OF RIVERS AND HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

REPORT *FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS. OFFICERS IN CHARGE, LIEUT. COL. G. J. LYDECKER AND CAPT. C. M'D. TOWNSEND, CORPS OF ENGINEERS.*

IMPROVEMENTS.

1. Michigan City Harbor, Indiana.
2. St. Joseph Harbor, Michigan.
3. St. Joseph River, Michigan.
4. South Haven Harbor, Michigan.
5. Saugatuck Harbor, Michigan.
6. Kalamazoo River, Michigan.
7. Holland (Black Lake) Harbor, Michigan.
8. Grand Haven Harbor, Michigan.
9. Grand River, Michigan.
10. Muskegon Harbor, Michigan.
11. White Lake Harbor, Michigan.
12. Pentwater Harbor, Michigan.
13. Ludington Harbor, Michigan.
14. Manistee Harbor, Michigan.
15. Harbor of Refuge at Portage Lake, Manistee County, Michigan.
16. Frankfort Harbor, Michigan.
17. Charlevoix Harbor, Michigan.
18. Petoskey Harbor, Michigan.

SURVEY.

19. Kalamazoo River, Michigan.

(For letter of transmittal, see Appendix L L.)

K K 1.

IMPROVEMENT OF MICHIGAN CITY HARBOR, INDIANA.

The improvements here, dating from 1836, have supplied an "inner harbor" for local commerce and partly completed an "outer harbor" designed to facilitate entrance to the former and to serve as a harbor of refuge.

The inner harbor.—This has been made by dredging so as to widen and deepen Trail Creek, and by building revetments and piers to protect the dredged channel. Before improvement the creek was a narrow, shallow stream, whose mouth was obstructed by a bar through which a crooked channel from 3 to 4 feet deep could be found under favorable conditions. The work done between 1836 and 1869 gave a good entrance channel with a depth of 12 feet at mean stages of water in Lake Michigan.

From 1869 to 1882 nothing was done on this portion of the harbor, except to make occasional repairs to the piers and dredge the channel

as needed to maintain the requisite navigable depth. In 1882 the project of operations was modified to provide for extending the harbor upstream, by dredging so far as the local authorities or property owners might build substantial revetments of approved design. In this way the total length of the inner harbor has grown to be about 1¾ miles (9,159 feet). At the beginning of the last fiscal year the channel depth at entrance was 13 feet, but above the entrance it was from 11 to 12 feet only; the total length of piers and revetments built by the Government was 3,572 feet, the width of channel way between them being 225 feet at entrance and narrowing to 100 feet about 500 feet above.

Operations during the last fiscal year were limited to dredging under contract with William A. Starke, of Milwaukee, Wis., as follows: In August, 1897, the lower winding basin was deepened, as also a section of the lower channel from stations 13+50 to 7+50, a distance of 600 feet; in May and June, 1898, a shoal that had formed a short distance inside of the entrance was removed and the upper portion of the channel was dredged. The total amount excavated during the year was 55,534 cubic yards.

The total expenditure on the inner harbor from 1836 to June 30, 1898, for improvement and maintenance, was $424,863.28, of which $5,269.82 were spent during the past fiscal year.

The condition of the work on the last-named date was as follows: The west pier had a length of 2,157 feet, as built by the Government; the inner section, from Station 0 to Station 7+85, has long been occupied by private parties and is in very poor condition, but the necessary repairs should be made by the occupants or owners of abutting property, as in all other parts of the interior channel; the outer section, comprising a length of 1,372 feet, must be cared for by the Government, and needs some minor repairs to keep it in serviceable condition. The east pier has a length of 1,415 feet, of which the inner 670 feet is in front of private property and in fair condition. The outlying section, about 745 feet long, is completely decayed above water, and about 115 feet of its outer end is gone to a depth of from 1 to 7 feet below the water surface. The channel depth at entrance was 13 feet and inside it was generally 12 feet, though slightly less in some places.

The estimate for the inner harbor for 1900 is as follows: For minor repairs of piers, dredging, and contingencies, $7,500.

Amount appropriated and expended from 1836 to 1869, inclusive	$287,388.92
Original estimated cost of project for inner harbor, 1870, revised in 1892.	131,375.00
Whole amount appropriated, 1870 to June 30, 1898	144,375.00
Whole amount expended, 1870 to June 30, 1898	137,479.51
Total expenditure from 1836 to June 30, 1898	424,863.28
Amount carried to surplus fund	5.15

Money statement.

July 1, 1897, balance unexpended		$12,165.31
June 30, 1898, amount expended during fiscal year		5,269.82
July 1, 1898, balance unexpended		6,895.49
July 1, 1898, outstanding liabilities	$168.11	
July 1, 1898, amount covered by uncompleted contracts	3,663.86	
		3,831.97
July 1, 1898, balance available		3,063.52
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		7,500.00

The outer harbor.—This part of the improvement comprises work done in the execution of projects prepared in 1870 and 1882, the former providing for an outer basin located to the east of the entrance to the inner harbor, and the latter for works exterior thereto, whose purpose was to give increased safety for vessels entering during heavy weather and provide a sheltered outside anchorage where vessels near this portion of Lake Michigan might find refuge against all northerly gales. The basin was completed in 1885, the structures then finished being as follows: (1) A pile pier, 1,225 feet long, extending in a northerly direction from the shore, and closing the basin on the east; (2) a crib breakwater, 30 feet wide, extending westwardly from the lake end of the pile pier for a distance of 1,411 feet, and covering the basin on the north; (3) the "breakwater pier," a crib structure 30 feet wide, extending northward from the west end of the crib breakwater for a distance of 355 feet, and designed, in connection with the "exterior breakwater," then about to be commenced, to lessen the dangers attendant upon attempts to enter the harbor when high seas prevail. A subsequent extension of 150 feet to this pier, making its total length 505 feet, brought work relating to the outer basin to the condition in which it has remained for several years past. Progress on the exterior breakwater has been very slow, only 700 feet of its total projected length having been completed between 1882 and 1895, and nothing has been done since then except to make occasional repairs.

Nothing was done on the outer harbor during the last fiscal year, except to replace a few deck plank that had been carried away by the wash of heavy seas. The property stored at the harbor was cared for as usual by the watchman, who is employed for that purpose, and who also maintains the lights at its entrance. This latter service is a considerable tax on the appropriation for improvement and is necessary, because the Light-House Establishment has made no provision for it.

The total amount expended in constructing and maintaining the works connected with the outer harbor to June 30, 1898, is $755,279.12, of which $1,318.66 were spent during the past fiscal year.

The outer harbor will have no value as a harbor of refuge until the exterior breakwater is completed, for not until then will vessels attempt to enter the basin or to anchor behind the breakwater. The result is, that the only benefits thus far derived from the large expenditure applied to this work are a reasonably safe entrance to the inner harbor and an obstruction to the run of high seas into it, thereby allowing vessels to lie easily at the wharves.

Since the adoption of the project for this breakwater the draft and size of vessels have increased so as to make it highly important that the project be modified. This matter was carefully considered by a Board of Engineers in 1897, and its recommendations, together with a map illustrating them, are printed in the Report of the Chief of Engineers for 1897, pages 2899 to 2904. The estimated cost of completing the work as there recommended is $280,150, or about $35,000 more than that of finishing the original project, and, as the latter is so poorly adapted to present requirements that it would be injudicious to pursue it further, the estimate for completion submitted below is that attaching to the modified project; but these figures are likely to be largely exceeded if operations be extended through several seasons under small appropriations. The economical and judicious course would be to appropriate $195,000, which, with the unexpended balance of previous appropriations, could be made to complete the work. The estimated

cost of completing, in accordance with the original project, would be $159,613.56, as stated in the last annual report.

The harbor is in the collection district of Chicago, Ill., which city is the nearest port of entry. The Light-House Establishment maintains a fifth-order coast light on the main shore. There is a life-saving station at the shore line east of the harbor entrance.

Original estimated cost of project for outer harbor, 1870	$324,421.40
Increase by cost of repairs and maintenance to 1882	90,067.10
Project for outer breakwater, including dredging of outer basin, 1882	587,000.00
Total estimate	1,001,488.50
Whole amount appropriated and allotted, 1870 to June 30, 1898	841,875.00
Whole amount expended, 1870 to June 30, 1898	755,279.12

Money statement.

July 1, 1897, balance unexpended	$87,914.54
June 30, 1898, amount expended during fiscal year	1,318.66
July 1, 1898, balance unexpended	86,595.88
Amount (estimated) required for completion of existing project	159,613.56
Amount that can be profitably expended in fiscal year ending June 30, 1900	159,613.56

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving harbor at Michigan City, Ind.

Date.	Outer harbor.	Inner harbor.	Total.
July 4, 1836			$20,000.00
March 3, 1837			30,000.00
July 7, 1838			60,733.59
June 11, 1844			25,000.00
August 30, 1852 a			20,000.00
March 2, 1855 (claim of J. R. Bowes)			470.33
June 23, 1866			75,000.00
July 25, 1868 (allotment)			25,000.00
April 10, 1869 (allotment)			31,185.00
July 11, 1870	$25,000.00		25,000.00
March 3, 1871	15,000.00		15,000.00
June 10, 1872	50,000.00		50,000.00
March 3, 1873	50,000.00		50,000.00
June 23, 1874	50,000.00		50,000.00
March 3, 1875	50,000.00		50,000.00
August 14, 1876	35,000.00		35,000.00
June 18, 1878	50,000.00	$25,000.00	75,000.00
1878 (allotment)	2,500.00		2,500.00
March 3, 1879	40,000.00		40,000.00
June 14, 1880	40,000.00	15,000.00	55,000.00
March 3, 1881	20,000.00	25,000.00	45,000.00
August 2, 1882	60,000.00	20,000.00	80,000.00
July 5, 1884	40,000.00	10,000.00	50,000.00
August 5, 1886	54,375.00	1,875.00	56,250.00
August 11, 1888	90,000.00	5,000.00	95,000.00
September 19, 1890	50,000.00	7,500.00	57,500.00
July 13, 1892	30,000.00	15,000.00	45,000.00
August 18, 1894	20,000.00	10,000.00	30,000.00
June 3, 1896	70,000.00	10,000.00	80,000.00
Total	841,875.00	144,375.00	1,273,638.92

a Amount carried to surplus fund, $5.15.

Abstracts of bids for dredging at harbors on east shore of Lake Michigan, received and opened March 30, 1898, in accordance with advertisement dated February 28, 1898.

No. of bid.	Name and address of bidder.	Dredging (price per cubic yard).	Transfer of plant (price per mile).
		Cents.	
a 1	William A. Starke, Milwaukee, Wis	14	$2.00
2	C. E. Mitchell & Co., Ludington, Mich	14½	2.00
3	Samuel O. Dixon, Racine, Wis	14½	3.00
4	Adolph F. Bues, Milwaukee, Wis	15	3.00
5	Arthur H. Vogel, Milwaukee, Wis	15	3.00
6	Green's Dredging Co., Chicago, Ill	15½	3.50

a Contract entered into April 9, 1898.

CONTRACTS IN FORCE FOR IMPROVING INNER HARBOR AT MICHIGAN CITY, IND.

William A. Starke, dredging, dated March 26, 1897; approved April 9, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, MICHIGAN CITY HARBOR, INDIANA, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	1,153	208,617	1893	1,577	589,868
1889	795	169,193	1894	889	119,929
1890	921	172,817	1895	343	91,016
1891	837	168,654	1896	437	106,543
1892	1,391	443,055	1897	492	118,137

NOTE.—No record is kept at Michigan City of traffic between this port and Chicago.

Receipts by vessel, 1897.

[Compiled from statements furnished by the collector of customs at Chicago, Ill., and the Michigan City harbor board.]

Articles.	Tons.	Articles.	Tons.
Coal	800	Potatoes	340
Fish	175	Salt	8,806
Fruit, miscellaneous	26	Ties	4,100
Iron or ore	700		
Lumber	115,838	Total	130,970
Merchandise, general	185		

K K 2.

IMPROVEMENT OF ST. JOSEPH HARBOR, MICHIGAN.

The object of improvements under the present approved project provide and maintain a navigable depth of 16 feet from Lake Mich to the upper limits of the harbor, and of 13 feet for an additiona tance of about 1 mile through the Benton Harbor Canal. Work commenced in 1836, when the natural entrance from Lake Michigan through a shifting channel, with depths fluctuating between 3 a feet. The improved channel is between piers 270 feet apart, but w do not extend far enough into Lake Michigan to provide an entr depth of more than 12 feet, and that only by repeated dredgings.

At the beginning of the last fiscal year the condition of the ha piers and revetments was as follows:

North pier and revetment, comprising 835 feet of pile work and feet of crib work, had a total length of 2,017 feet and projected a 960 feet beyond the shore line.

South pier, comprising 606 feet of pile work and 213 feet of crib w had a total length of 819 feet and projected about 520 feet from shore line; the piers terminated respectively at the curves of 20 15 feet depths in Lake Michigan. A section of the north pier 378 long was undergoing repairs amounting to a practical reconstruc an additional length of 303 feet needed similar treatment, and remaining length of 1,339 feet was in good or fair condition. The s pier had lost a large portion of its filling and commenced to show un takable indications that reconstruction would soon be imperative.

Operations during the last fiscal year comprised dredging in and August, 1897, and again in May and June, 1898, the total am excavated being 35,542 cubic yards. Work under a contract Eslow & Munroe, of Charlevoix, Mich., for rebuilding 375 linear fe the north pier had been commenced May 26, 1897, and was conti until October, 1897. The work then completed consisted in cu away the old pier above the level of zero of gauge, driving a re triple sheet piling of 3 by 12 inches by 24 feet white-pine planks on channel face, with a row of white-oak round piles 4 feet between cen along the front, and building a new 6-course superstructure, 18 wide, on top. The projecting low part of the old substructure on north side was decked with 6 by 12-inch timber. The pier was re with stones saved from the old work, and decked with 3 by 12 planks.

The result of the dredging was to maintain navigation through harbor and canal, but the money available was not sufficient to vide such a channel as the local commerce required; this was espec the case respecting the depth at entrance, which became so red that the large steamer *City of Duluth* struck heavily in attempti make the harbor last winter, while a high sea was running, and be a total wreck. The result of the repairs to the pier was to conv wholly dilapidated and unserviceable section into a substantial s tight structure, and make it practically as good as new. In all r respects the condition of the channel and harbor piers was abou same at the close as at the beginning of the year, but the serious dition of the south pier had become much more apparent. The s able depth into and through the harbor and Benton Harbor Canal 13 feet, as a result of the dredging done in May and June; but ex ence shows that this depth will not last long, and as there is no

money for further operations at this harbor it is very likely that local commerce will become seriously affected during the ensuing fiscal year.

The total expenditure for improvements and their maintenance from 1836 to June 30, 1898, was $490,614.32, of which $11,570.58 were spent during the last fiscal year.

In order to accomplish and maintain the improvements called for by the present approved project it is essential that the remaining unserviceable parts of the old piers be thoroughly repaired, that the piers be extended to at least 18 feet of water beyond the outer bar, and that both sides of the Benton Harbor Canal be protected by sand-tight revetments; but this last item should not be at the expense of the United States. The canal, which is wholly artificial, was started by local enterprise, and was but little more than a ditch when, in 1880, the United States undertook to do the dredging required to make it a commercial waterway 100 feet wide and 13 feet deep, but this was done subject to the express agreement by the local authorities that they would cause substantial revetments to be made and maintained on both sides. The United States has faithfully carried out its part of the bargain for eighteen years, but the local authorities have not, and it would now seem to be highly proper for the former to suspend work on this canal until the latter have complied with their obligations respecting it, by causing the proper revetments to be built and maintained. This principle is strictly adhered to at the neighboring harbor of Michigan City, though the interior navigation there is through an improved natural waterway, while that from St. Joseph to Benton Harbor is altogether artificial.

The estimated cost of completing and maintaining the improvement under the present approved project is as follows:

850 linear feet of crib pier extension	$85,000
Rebuilding south pier, 820 linear feet, at $25 per linear foot	20,500
Minor repairs of other parts of old piers	2,000
Dredging, two seasons	10,000
Making in all, with due allowance for engineering, supervision, and office contingencies	127,000

A special report in relation to this harbor was submitted to Congress in response to a concurrent resolution of February 1, 1898, and printed as House Doc. 307, Fifty-fifth Congress, second session, and is submitted herewith.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a fourth-order revolving coast light on the bluff south of the harbor, and range lights and fog-bell on the north pier. There is a life-saving station near the east end of north pier.

Original estimated cost of work as revised in 1892	$519,113.00
Whole amount expended to June 30, 1898	490,614.32

Money statement.

July 1, 1897, balance unexpended	$14,068.46
June 30, 1898, amount expended during fiscal year	11,570.58
July 1, 1898, balance unexpended	2,497.88
July 1, 1898, outstanding liabilities	251.69
July 1, 1898, balance available	2,246.19

Amount (estimated) required for completion of existing project	100,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	127,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving St. Joseph Harbor and River, Michigan.

July 4, 1836			$20,000
March 3, 1837			15,000
July 7, 1838			51,113
March 3, 1843			25,000
June 11, 1844			20,000
August 30, 1852 *a*			10,000
June 28, 1864 (allotment)			15,000
June 23, 1866			6,000
March 2, 1867			23,000
Allotted from harbors on Northwestern Lakes, 1867	$7,500		
Transferred in 1870 to Grand Haven Harbor	500		
			7,000
July 11, 1870			15,000
March 3, 1871			10,000
June 10, 1872			3,000
June 23, 1874			$2,000
March 3, 1875			35,000
August 14, 1876			12,000
June 18, 1878			12,000
March 3, 1879			6,000
June 14, 1880			8,000
March 3, 1881			10,000
August 2, 1882			12,000
July 5, 1884			15,000
August 5, 1886			10,000
August 11, 1888			12,000
September 19, 1890			20,000
July 13, 1892			59,000
August 18, 1894			30,000
June 3, 1896			30,000
Total			493,113

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT ST. JOSEPH, MICHIGAN.

William A. Starke, dredging, dated March 26, 1897; approved April 9, 1897; date of beginning April 1, 1897; date of expiration September 15, 1897.

Eslow & Munroe, pier work, dated May 3, 1897; approved May 20, 1897; date of beginning May 1, 1897; date of expiration October 1, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning April 15, 1898; date of expiration September 15, 1898.

REPORT OF CAPT. C. M'D. TOWNSEND, CORPS OF ENGINEERS, IN REFERENCE TO A MODIFICATION OF THE PLAN FOR THE IMPROVEMENT OF THE HARBOR AT ST. JOSEPH AND BENTON HARBOR, MICH.

[Printed in House Doc. No. 307, Fifty-fifth Congress, second session.]

UNITED STATES ENGINEER OFFICE,
Grand Rapids, Mich., December 13, 1897.

GENERAL: I have the honor to transmit the following report in compliance with the Department indorsement of November 26, 1897, on the letter of November 20, from the Hon. E. L. Hamilton to the Secretary of War, in reference to a modification of the plan for the improvement of the harbor at St. Joseph and Benton Harbor, Mich.

The harbor of St. Joseph is formed by the junction of the St. Joseph and Paw Paw rivers, and extends along the city front of St. Joseph with a width of about 800 feet in its natural state, ultimately to be reduced to a width slightly exceeding 300 feet when wharves are constructed on the harbor lines recently approved by the Secretary of War. Benton Harbor is connected with St. Joseph Harbor by a canal about 1 mile in length and 100 feet in width. The outlet of the harbor into Lake Michigan is protected by piers constructed of piling and timber cribs, having a width between them of 270 feet.

The project for its improvement provides for a navigable channel of a depth of 16 feet from Lake Michigan to the upper limits of the city of St. Joseph, and of 13 feet thence to Benton Harbor, and will require the extension of the north pier 850 feet to complete it. The north pier

a Amount carried to surplus fund, 80 cents.

has recently been rebuilt, and under the existing project the next appropriation will be employed in extensive repairs to the south pier, which is in a precarious condition. If the modifications of the project which Mr. Hamilton suggests are to be made, Congressional action is desirable before further work is undertaken.

As a survey of this harbor has not been authorized, I inclose a tracing* giving contours deduced from the last general survey (in 1894) and soundings in the channel taken after the close of this season's operations, which indicate that no material change of conditions has occurred since the date of survey.

The harbor is annually dredged to the depth required by the project, and as regularly refills. A flood in either the Paw Paw or St. Joseph River brings down a large amount of sand, which is liable to form a bar near their junction having depths over it not exceeding 10 feet, and storms in Lake Michigan obliterate the channel dredged beyond the end of the south pier. A bar with a depth over it of about 12 feet tends to form between the ends of the north and south piers. Sand flows into the channel around the end of the north pier, and an outer bar develops about 600 feet beyond the north pier. The depths on these bars are modified, not only by the direction of storms in Lake Michigan, but by the stage of the rivers which here empty into it.

The further extension of the north pier, as provided for in the existing project, may increase the depths over these bars, but the experience at this harbor has been sufficient to show that it can not alone prevent their recurrence. While the storms from the north to west have a greater intensity at this harbor than those from any other direction, due to the extent of lake over which they sweep, a gale from the southwest has sufficient force to move large quantities of sand. The frequency with which southwesterly winds occur compensates to some extent for their lack of intensity, particularly in the shoal water to which the piers now extend, nor can the flow of the rivers be relied upon to correct their influence, as at the time the lake storms have the greatest violence the river flow is the least.

As explained by Mr. Hamilton, the commerce at this harbor is rapidly increasing, and the recent introduction of car ferries gives an importance to its winter navigation that it did not formerly possess. During the period that the Straits of Mackinac and the St. Marys River are closed by ice, and the ferriage of cars across Lake Michigan has therefore its greatest influence in modifying rates on transcontinental shipments of freight, the formation of bars in front of this harbor is most liable to occur, and can be removed by dredging only with great difficulty. A modification of the existing project I therefore consider worthy and justified by the interests involved.

The question of the width between piers requires careful consideration. To facilitate the entrance of vessels during storms, as great a width as practicable should be given to the harbor entrance, but it must be borne in mind that the entrance of waves will also be facilitated thereby. The established distance between harbor lines at St. Joseph slightly exceeds 300 feet, and affords little space in which waves can disperse after entering the harbor. A width of 400 feet between piers at their outer ends, narrowing to 300 feet at the shore line, as proposed by Mr. Hamilton, would form a funnel-shaped entrance which would expose the entire harbor to the full force of a westerly gale. Under existing conditions waves sometimes enter the harbor with sufficient

*Not reprinted. Printed in House Doc. No. 307, Fifty-fifth Congress, second session.

force to render it dangerous for small craft to lie at the wharves. The removal of the existing south pier is not therefore considered advisable.

The large freighters, of lengths exceeding 400 feet, are now employed economically between large centers of commerce, such as Chicago and Duluth on the one hand, and Cleveland and Buffalo on the other, but their profitable employment in the commerce of cities situated like Benton Harbor and St. Joseph is yet to be demonstrated. There is, however, a necessity for depths that will admit safely the large car ferries, which have a length of about 300 feet and a draft of 14½ feet. Such a boat will require a depth of at least 15 feet through the Benton Harbor Canal, and of at least 18 feet at the harbor entrance to prevent striking the bottom during storms. With such depths the largest freighters could enter the harbor during fair weather, and if it is shown that there is a demand for this class of vessels the project can then be further modified so as to afford them ample security during storms.

To deepen the harbor over the entire area included between harbor lines to the depths above indicated, and construct a turning basin at the upper end of the Benton Harbor Canal of a capacity required by large freighters, will require the excavation of 816,880 cubic yards of material. The present needs of the harbor will, however, be served by the excavation of a channel way 150 feet wide along the front of the city of St. Joseph, with a turning basin at the mouth of the St Joseph River, which to some extent will also act as a catch-basin for sand during floods in that river. Further development can be postponed until the commercial growth of the harbor demonstrates the necessity.

I have therefore to recommend the following modifications of the existing project for the improvement of St. Joseph Harbor: That the north pier be extended to the 20-foot contour and the south pier to the 18 foot on a line parallel to it, as shown on the accompanying tracing: that the entrance to the harbor and a space 150 feet wide along the city front of St. Joseph be dredged to a depth of 18 feet, and that the Benton Harbor Canal and a turning basin at the mouth of the St. Joseph River be dredged to a depth of 15 feet. The following is an estimate of the cost of the work:

Pier extension:	
2,000 feet, at $110	$220,000
800 feet, at $90	72,000
Repairs to piers	20,000
Dredging:	
St. Joseph Harbor, 129,100 cubic yards, at 15 cents	19,365
Benton Harbor Canal and turning basin, 99,300 cubic yards, at 15 cents.	14,895
	346,260
Contingencies	33,740
Total	380,000

It is also estimated that there will annually be required for maintenance at this harbor $10,000. The sands carried into the harbor by spring floods can not be carried to deep water in the lake by the river discharge unless the waterway be contracted to an extent that would preclude navigation by large vessels. The works herein proposed will protect the harbor from the formation of bars caused by the waves of Lake Michigan. The deposit from floods occurs at a period when it can be readily removed by dredging.

Very respectfully, your obedient servant,

C. McD. TOWNSEND,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS, ST. JOSEPH AND BENTON HARBOR, MICH., FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Vessels entered.		Vessels cleared.	
	Number.	Tonnage.	Number.	Tonnage.
1890	948	131,607	946	131,395
1891	742	215,334	743	215,591
1892	1,726	707,285	1,727	707,785
1893	1,576	1,125,063	1,575	1,125,938
1894	1,100	900,000	1,100	900,000
1895	779	827,384	727	827,837
1896	835	439,031	833	435,033
1897	842	385,915	849	348,040
ENTRANCES AND CLEARANCES AS REPORTED BY GRAHAM & MORTON TRANSPORTATION COMPANY.				
1897	1,015	1,115,565	987	989,062

Receipts and shipments by vessel at St. Joseph and Benton Harbor, Mich., 1897.

[Compiled from statements furnished by the Graham & Morton Transportation Company of Benton Harbor, Mich., and the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Coal	1,420	Fish	268
Flour	77,019	Flour	3,757
Grain	13,174	Fruit	41,656
Gravel	724	Hay and feed	60
Hay and feed	4,825	Lime and cement	606
Lime and cement	2,868	Live stock	59
Live stock	67	Logs	569
Lumber	22,904	Lumber	1,725
Machinery	225	Machinery	375
Merchandise, general	125,366	Merchandise, general	71,661
Paper	2,135	Paper	1,063
Pig iron	1,996	Pig iron	1,325
Salt	14,694	Potatoes	1,546
Wood	335	Salt	3,347
Total	267,752	Total	128,017

In addition to classified tonnage, car ferries carried 39,625 freight cars, average weight 21 tons, making 832,125 tons.

K K 3.

IMPROVEMENT OF ST. JOSEPH RIVER, MICHIGAN.

This is a very crooked stream, obstructed by numerous shoals and ripples over which the water flows in thin sheets, with depths in channel crossings of from 24 to 30 inches; the intervening pools are generally from 4 to 8 feet deep. The only part now navigated is from the mouth at St. Joseph to Berrien Springs, a distance of about 25 miles by river, while the land distance between the same points is but little more than half that.

A project for improving this section, to the extent of providing a low-water channel 3 feet deep, was approved March 27, 1889, and has been followed as far as possible with the small appropriations that have been made since that time. The work has consisted in removing snags and

sunken logs, closing secondary channels by dams made of logs, brush and stone, and building and maintaining wing dams of similar construction for concentrating the flow in other parts of the stream; many of the worst places have been thereby improved to the required extent, but other shoals remain unimproved, and the inexpensive dams heretofore constructed call for repairs and additions from year to year.

During the past fiscal year two new wing dams were built, one being at Shaker Farm, the other at Hipp's Shoal; repairs were made to dams at Hipp's Shoal, Twin Springs, Brown's Shoal, Sawyer's Landing, Tabor's Landing, King's Landing, and Long Reach, and a number of snags were removed at various points.

The total expenditure for improvement and repairs to June 30, 1898, was $5,285.74, of which $423.72 were expended during the last fiscal year.

The cost of improving the stream was estimated in 1880 at $11,300, but that estimate related to cost of original construction only. Improvements of this character require more or less work each year, and the cost of completion is wholly a matter of how long the work is to be kept up, and the average annual cost of doing it. In the present instance the mean annual expenditure has been $500, and experience shows that it is too little to accomplish what the approved project requires, but $750 would probably suffice; on this basis the next appropriation should be $1,500 if the improvement is to be maintained, and the established custom of making such appropriations only once in two years is adhered to. The estimate submitted below is therefore put in that form.

Amount required for maintaining improvement to June 30, 1901	$1,500.00
Amount that can be profitably expended in year ending June 30, 1900	750.00

Money statement.

July 1, 1897, balance unexpended	$637.98
June 30, 1898, amount expended during fiscal year	423.72
July 1, 1898, balance unexpended	214.26
Amount (estimated) required for completion of existing project	5,800.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	1,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving St. Joseph River, Michigan.

August 11, 1888	$2,500
September 19, 1890	1,000
July 13, 1892 (allotment)	1,000
August 18, 1894	500
June 3, 1896	500
Total	5,500

Whole amount expended to June 30, 1898, 5,285.74.

COMMERCIAL STATISTICS, ST. JOSEPH RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

The steamers *May Graham* and *Tourist* carried 30,000 passengers and 6,175 tons miscellaneous freight between St. Joseph and Berrien Springs.

feet. The original project was subsequently modified to make the
nce width between piers 177 feet and extend the navigable channel
eam to the highway bridge, about half a mile above the piers. The
length of piers and revetments built up to the year 1888 aggregated
feet, and no extensions have been made to them since that time.
the beginning of the last fiscal year the condition of the harbor
and revetments was as follows: North pier and revetment, com-
ıg 607 feet of crib work and 987 feet of pile work, had a total length
94 feet and projected about 650 feet beyond the shore line; south
ınd revetment, comprising 557 feet of crib work and 997 feet of
'ork, had a total length of 1,554 feet and projected 470 feet beyond
ıore line; the piers reached respectively to the curves of 12 and 9
lepths in Lake Michigan. The available depth at entrance was 12
s a result of some dredging that had just been completed.
'en hundred and eighty linear feet of piers are from twenty to
' years old, and most of this distance should be rebuilt above water
ıut delay.
ontract had been entered into with Eslow & Munroe, of Charle-
Mich., for an extension of 300 feet to the south pier, but up to the
ning of the last fiscal year only a part of the necessary material
een delivered. Work was commenced July 14, and continued till
ember 16, when operations ceased, as the result of a storm which
place that night. The work that had been in progress was intended
a sand-tight pier, with Wakefield sheet piling on front and rear,
n cross walls at each end and intermediately at intervals of 48 or
et; the spaces inclosed by the sheet piling were to be compactly
with sand. The structure was of such a nature that it could not
pected to be safe against any severe storm until the filling was in
, and the contractor's failure to carry on his work with any regard
ever for this important consideration was the sole cause of the dis-
that befell him. The condition of his work September 16 was as
ws:
the front wall, 220 linear feet of the round piling, part of the wale

The only other work done at the harbor during the year was by William A. Starke, of Milwaukee, Wis., under his contract of April 9, 1898. This work was commenced May 26 and completed June 13, 1898, and consisted in dredging a channel 75 feet wide and 17 feet deep, extending from a point 400 feet outside to one about 100 feet inside of the harbor piers, and its extension with a width of 50 and depth of 15 feet for a further distance of 800 feet inside. A single cut 25 feet wide, 15 feet deep, and about 300 feet long was also made near the upper end of the harbor to facilitate approach to the turning basin at that place. The total amount dredged was 13,766 cubic yards, and while the resultant benefits will be only temporary, they will probably last long enough to permit a draft of from 11 to 12 feet until the close of the busy season.

No work having been done on the old piers or revetments, they remain at the end of the year about as they were at its beginning, but somewhat worse as a result of the additional wear and tear.

The total expenditure for improvements and their maintenance to June 30, 1898, was $235,636.31, of which $4,807.84 were spent during the last fiscal year.

When the south pier extension now in progress is finished the present approved project of construction will be completed, but the navigable depth called for by that project can not be obtained and kept until both piers are extended to at least the 14-foot curve in Lake Michigan. This would require further extensions of 300 and 100 feet to the north and south piers, respectively, but no estimate for such work has yet been called for or authorized.

For maintenance of the improvement extensive repairs of the old piers are urgently needed, and annual dredging can not be dispensed with if navigation is to be kept up. At least $15,000 is required for these purposes, including supervision, engineering, and office expenses.

A special report in relation to this harbor, dated January 21, 1897, was submitted to Congress by the officer then in charge of the work, in compliance with the provisions of the river and harbor act of June 3, 1896, and published as House Ex. Doc. 279, Fifty-fourth Congress, second session. The estimated cost of what is needed to accomplish the present approved plan of improvement was then as follows, and I concur in that estimate:

Repairs to pile revetment, 1,130 feet, at $12	$13,560
Repairs to cribs, 708 feet, at $12	8,496
Repairs to cribs, 405 feet, at $15	6,075
Pier extension, 700 feet, at $90	63,000
Dredging, 50,000 cubic yards, at 15 cents	7,500
	98,631
Contingencies	9,869
Total	108,500

This harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a harbor light on the south pier. There is a life-saving station near the inner end of the north pier.

Original estimated cost of work, 1866, amended in 1869, 1872, and 1892 ... $262,000.00
Whole amount expended to June 30, 1898 ..... 235,636.31

Money statement.

July 1, 1897, balance unexpended		$21,171.53
June 30, 1898, amount expended during fiscal year		4,807.84
July 1, 1898, balance unexpended		16,363.69
July 1, 1898, outstanding liabilities	$516.29	
July 1, 1898, amount covered by uncompleted contracts	11,652.00	
		12,168.29
July 1, 1898, balance available		4,195.40
Amount (estimated) required for completion of existing project		45,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		15,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations for improving harbor at South Haven, Mich.

March 2, 1867	$43,000	March 3, 1881	$5,000
July 11, 1870	10,000	August 2, 1882	10,000
March 3, 1871	15,000	July 5, 1884	7,500
June 10, 1872	12,000	August 5, 1886	5,000
March 3, 1873	20,000	August 11, 1888	10,000
June 23, 1874	10,000	September 19, 1890	15,000
March 3, 1875	10,000	July 13, 1892	10,000
August 14, 1876	10,000	August 18, 1894	20,000
June 18, 1878	12,000	June 3, 1896	15,000
March 3, 1879	7,500		
June 14, 1880	5,000	Total	252,000

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT SOUTH HAVEN, MICH.

William A. Starke, dredging, dated March 26, 1897, approved April 9, 1897. Date of beginning, April 1, 1897; date of expiration, September 15, 1897.

Eslow & Munroe, pier work, dated May 6, 1897, approved May 24, 1897. Date of beginning, May 15, 1897; date of expiration November 1, 1897, extended to September 1, 1898.

William A. Starke, dredging, dated April 9, 1898, approved April 20, 1898. Date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, SOUTH HAVEN HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1889 (estimated)	1,080		1894	3,246	228,246
1890	2,246	128,880	1895	3,222	238,060
1891	2,994	201,380	1896	1,218	343,016
1892	3,060	212,160	1897	1,256	351,000
1893	3,822	251,730			

A new line of boats was established during the year by the South Haven and Chicago Transportation Company.

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by C. J. Monroe, esq., South Haven, Mich.]

Articles received.	Tons.	Articles shipped.	To
Brick	900	Brick	
Coal	7,500	Farm products	
Flour	550	Flour	
Grain	150	Fruit	1
Hay and feed	1,500	Gravel	
Iron and machinery	500	Leather	
Leather	300	Live stock	
Lime and cement	1,000	Lumber	
Lumber	6,965	Machinery	
Merchandise, general	6,700	Merchandise, general	
Paper	50	Potatoes	
Salt	600	Slabs	
Stone	1,500	Stone	
Tan bark	3,900		
Total	32,115	Total	3

In addition to the above, a total of 45,000 passengers was carried by vessels t ing at this port.

K K 5.

IMPROVEMENT OF SAUGATUCK HARBOR, MICHIGAN.

The progress of this improvement to June 30, 1897, is summarize the Report of the Chief of Engineers for that year, pages 2913, 291

Operations during the last fiscal year were limited, as has been u for the past sixteen or eighteen years, to dredging for the purpos making an outlet for navigation during the short period required shipping the local fruit products. That for the season of 1897 done in July, and for 1898 in June; the total amount excavated du the year was 24,553 cubic yards, all under contract with William Starke, of Milwaukee, Wis.

The port of shipment out of this harbor is the town of Saugat which is on the Kalamazoo River, 3 miles above the harbor. eventual abandonment of the present improvement is foreshadowe the following provision of the river and harbor act of June 3, 1896

Improving Kalamazoo River, Michigan, from Lake Michigan to Saugatuc accordance with the alternative project submitted January twenty-eighth, eigh hundred and ninety-six, five thousand dollars.

While the foregoing adopts the project and authorizes the comme ment of work on it, the amount appropriated is wholly inadequate explained in the following report on the improvement of Kalama River. As the old route must serve until the new one can replac it will be necessary to continue appropriations in the meantime opening the channel for a limited period annually, as has been the tom in recent years; an estimate of $10,000 is therefore submitted this purpose, including superintendence, engineering, and office con gencies.

This harbor is in the Grand Haven collection district, and the nearest port of e is Grand Haven, Mich. The Light-House Establishment maintains a fifth-order c light on the north side of the entrance and a harbor light near the end of the s pier.

Original estimated cost of the work, 1867, modified in 1869, 1870, 1875, and 1892	$175,69
Whole amount expended to June 30, 1898	165,34

Money statement.

July 1, 1897, balance unexpended		$8,678.89
June 30, 1898, amount expended during fiscal year		6,580.05
July 1, 1898, balance unexpended		2,098.84
July 1, 1898, outstanding liabilities	$1,354.94	
July 1, 1898, amount covered by uncompleted contracts	513.06	
		1,868.00
July 1, 1898, balance available		230.84
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867, and of sundry civil act of June 4, 1897.		10,000.00

Appropriations for improving harbor at Saugatuck, Mich.

July 25, 1868 (allotment)	$23,900	June 14, 1880	$5,000
April 10, 1869 (allotment)	6,039	March 3, 1881	5,000
July 11, 1870	10,000	August 2, 1882	8,000
March 3, 1871	10,000	July 5, 1884	4.000
June 10, 1872	15,000	August 5, 1886	8,000
March 3, 1873	10,000	August 11, 1888	5,000
June 23, 1874	10,000	July 13, 1892	5,000
March 3, 1875	10,000	August 18, 1894	12,000
August 14, 1876	3,000	June 3, 1896	10,000
June 18, 1878	2,500		
March 3, 1879	5,000	Total	167,439

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT SAUGATUCK, MICH.

William A. Starke, dredging, dated March 26, 1897, approved April 9, 1897. Date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898, approved April 20, 1898. Date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, SAUGATUCK HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	262	132,400	1893	626	162,632
1889	314	70,300	1894	862	106,000
1890	178	42,000	1895	1,256	134,918
1891	492	120,000	1896	848	153,190
1892 a			1897	586	70,360

a Not stated.

Receipts and shipments by vessel.

[Compiled from statement furnished by Messrs. Griffin & Henry, Saugatuck, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Coal	500	Farm products	7
Lime and cement	52	Fish	75
Lumber	1,440	Fruit	2,287
Merchandise, general	476	Live stock	35
		Potatoes	144
Total	2,468	Total	2,548

K K 6.

IMPROVEMENT OF KALAMAZOO RIVER, MICHIGAN.

The river and harbor act of June 3, 1896, provided the following in relation to this proposed improvement:

Improving Kalamazoo River, Michigan, from Lake Michigan to Saugatuck, in accordance with the alternative project submitted January twenty-eighth, eighteen hundred and ninety-six, five thousand dollars.

The alternative project referred to is printed in the report of the Chief of Engineers for 1896, pages 2741 to 2743, the purpose being to establish a shorter and more easily maintained line of water communication from Saugatuck to Lake Michigan than that now afforded through Saugatuck Harbor. It provides for dredging the river from the town to a point 1¾ miles below it, and thence making a new cut, 12 feet deep, through to Lake Michigan; the estimated cost is $150,000.

The essential feature is the cut from river to lake, and the construction of revetments and piers that are necessary for giving any degree of permanence. The appropriation of $5,000 is altogether too small to justify a commencement of the work, and it would be most injudicious, if not really foolish, to make a beginning until the whole amount of the estimate is appropriated. Accordingly no work has yet been done.

Money statement.

July 1, 1897, balance unexpended	$5,000.00
June 30, 1898, amount expended during fiscal year	.25
July 1, 1898, balance unexpended	4,999.75
Amount (estimated) required for completion of existing project	145,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	145,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

K K 7.

IMPROVEMENT OF HARBOR AT HOLLAND (BLACK LAKE), MICHIGAN.

The work of improving this harbor was commenced by the Government in 1867 and continued until 1880, when piers and revetments aggregating 3,545 feet had been built. No additions have been made since then, all work in the meantime having been in the nature of repairs and dredging.

Operations during the last fiscal year consisted in dredging the channel way between the piers, under contract with William A. Starke, of Milwaukee, Wis., dated April 19, 1898, the work being done between May 3 and May 21, 1898, and the amount excavated 12,088 cubic yards. A section of the north pier 203 feet in length was rebuilt, as described in the following extract from the report of Mr. F. W. Lehnartz, assistant engineer, in local charge:

In the beginning of the fiscal year the pile work just east of the part of the pier repaired in 1896 began to fail and it became necessary to make immediate repairs. A contract was therefore entered into with Love & West, and operations commenced August 6. The repairs consist of a row of triple-sheet piling of 3 by 12 inch by 30 foot white-pine planks, protected in front by a row of white-oak piles, 4 feet between centers and 36 feet long in the work, with an oak wale at water surface and iron tie-rods to the rear wall of the old structure every 8 feet. The top of the round and sheet piles is 5 feet above zero of gauge. At the west end the new work connects with and continues the alignment of the new front wall built in 1896, being

approximately 6 feet in front of the old work; at the east end the new work connects with the old at an angle of about 45 degrees. Connection is made between the new and old front walls by means of 12 by 12 inch timber braces every 8 feet. The new work has a length of 203 feet, and extends from station 7 + 69.5 to 9 + 72.5.

The total amount expended for improving the harbor to June 30, 1898, was $299,533.76, of which $4,501.66 were spent during the past fiscal year.

The condition of the harbor at the close of the year was as follows: North pier, consisting of 1,137 feet of pile work and 717 feet of crib work, had a total length of 1,854 feet and projected 480 feet beyond the shore line. The pier is generally in poor condition and requires extensive repairs, amounting to a practical rebuilding in some portions. The south pier, comprising 993 feet of pile work and 698 feet of crib work, had a total length of 1,691 feet and projected 705 feet beyond the shore line. This pier also requires extensive repairs, including reconstruction for a distance of about 225 feet. As a result of dredging just then completed the maximum available depth at the shoalest part of the channel June 30, 1898, was 12 feet.

The estimate herewith for 1900 is limited to what is necessary for restoring or maintaining the old piers in serviceable condition, and for dredging to maintain the requisite channel depth, as follows: For 1,000 linear feet of sheet piling, $10,000; rebuilding 833 feet of piers above water, $10,000; dredging, $5,000; making in all, with due allowance for supervision, engineering, and office contingencies, $27,500.

A special report, dated January 5, 1897, containing an estimate of cost of obtaining a 16-foot depth of channel was made to Congress under the provisions of the river and harbor act of June 3, 1896, and is printed in Report of the Chief of Engineers, United States Army, for 1897, pages 2950–2951, and also House Ex. Doc. 272, Fifty-fourth Congress, second session. The estimate was as follows:

Pier extension:	
600 feet, at $90	$54,000
900 feet, at $120	108,000
Reconstruction of pile revetment, 2,110 feet, at $15	31,650
Repairs to 246 feet crib work, at $25	6,150
Repairs to 510 feet crib work, at $12	6,120
Repairs to 653 feet crib work, at $4	2,612
Dredging 64,000 cubic yards, at 15 cents	9,600
	218,132
Contingencies	21,868
Total	240,000

The harbor is in the Grand Haven collection district and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a harbor light near the outer end of the south pier. There is a life-saving station near the inner end of south pier.

Original estimated cost of the work, 1866, amended in 1873, 1879, 1884, and 1892	$291,615.31
Whole amount expended to June 30, 1898	304,035.42

Money statement.

July 1, 1897, balance unexpended	$5,080.36
June 30, 1898, amount expended during fiscal year	4,501.66
July 1, 1898, balance unexpended	578.70
July 1, 1898, outstanding liabilities	169.23
July 1, 1898, balance available	409.47
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	27,500.00

Appropriations for improving harbor at Holland (Black Lake), Mich.

Black Lake:	
August 30, 1852*	$8,000.00
June 23, 1866	55,615.31
March 2, 1867	51,000.00
July 11, 1870	10,000.00
March 3, 1871	10,000.00
June 10, 1872	10,000.00
March 3, 1873	12,000.00
June 23, 1874	15,000.00
March 3, 1875	15,000.00
August 14, 1876	15,000.00
June 18, 1878	10,000.00
March 3, 1879	6,000.00
June 14, 1880	6,000.00
Black Lake—Continued:	
March 3, 1881	$6,000.00
August 2, 1882	10,000.00
July 5, 1884	15,000.00
August 5, 1886	5,000.00
August 11, 1888	5,000.00
September 19, 1890	10,000.00
Holland:	
July 13, 1892	5,000.00
August 18, 1894	15,000.00
June 3, 1896	10,000.00
Total	304,615.31

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT BLACK LAKE, MICHIGAN.

Green's Dredging Company, dredging, dated March 26, 1897, approved April 14, 1897; date of beginning, April 1, 1896; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898, approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, BLACK LAKE HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1889	1,087	80,790	1894	1,816	159,657
1890*a*			1895	809	210,290
1891	2,676	178,300	1896	408	269,182
1892	2,800	200,000	1897	456	153,852
1893	2,060	315,150			

a Not stated.

Entrance and clearances as reported by W. H. Beach, of Holland, Mich., for 1897, 962; tonnage, 186,610.

Receipts and shipments by vessel, 1897.

[Compiled from statements furnished by W. H. Beach, esq., of Holland, Mich., and the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick and stone	2,860	Coal	690
Coal	2,450	Flour	5,570
Flour	70	Farm products	250
Grain	7,200	Fruit	996
Gravel	4,400	Grain	300
Hides	56	Hay and feed	7,900
Iron and machinery	360	Hides	491
Lime and cement	414	Leather	8,200
Lumber	58,003	Lime and cement	70
Merchandise, general	9,741	Live stock	100
Miscellaneous	12,200	Lumber	5,000
Salt	64	Machinery	375
Stone	4,960	Merchandise, general	3,000
Tan bark	21,450	Miscellaneous	26,984
Total	124,238	Total	59,925

*Amount carried to surplus fund, $1.19.

K K 8.

IMPROVEMENT OF GRAND HAVEN HARBOR, MICHIGAN.

This harbor is at the mouth of Grand River, which had a shifting channel with a depth of 9 feet at its mouth before improvement, toward which some steps had been taken by the Detroit, Grand Haven and Milwaukee Railroad Company, when systematic work was commenced by the Government in 1867, under an appropriation of $65,000 made in the river and harbor act of June 23, 1866. The project adopted was the usual one of protecting the entrance channel by piers projecting into the lake, and dredging as found necessary to make and maintain the required depth of 18 feet. The total length of piers and revetments in place at the beginning of the last fiscal year was 9,312 feet, of which 1,060 feet are twenty years old or over.

The then available channel depth was 16½ feet.

Operations during the last fiscal year comprised dredging and repairs to piers as follows: From July 6 to September 2, 1897, a portion of the interior channel, 1,600 feet long and 180 feet wide, was dredged under contract with Green's Dredging Company, dated March 26, 1897, the total excavation being 40,942 cubic yards. The work of pier repairs was done by hired labor, and consisted principally in additions to the stone filling in the old pile sections of the pier work, and the introduction of new timbers where necessary to close gaps and retain the filling in place.

The total amount expended in improving this harbor up to June 30, 1898, is $738,767.73, of which $11,501.96 were spent during the last fiscal year.

The condition of the harbor June 30, 1898, was as follows: The north pier and revetment, comprising 2,136 feet of pile work and 1,412 feet of crib work, had a total length of 3,538 feet and projected 1,472 feet beyond the shore line. The south pier and revetment, comprising 4,267 feet of pile work and 1,507 feet of crib work, had a total length of 5,774 feet and projected 1,680 feet beyond the shore line. The timber work of these piers was generally in fair condition, but a large amount of filling is needed to retain them in serviceable condition.

The available channel depth was 17 feet.

The estimate for 1900 is as follows: For 150 feet of crib pier extension, $18,000; for restraining drift of sand over the piers and revetments, $7,000; incidental repairs, $7,000—making, in all, with due allowance for supervision, engineering, and office contingencies, $35,000.

This harbor is at the port of entry for the Grand Haven collection district. The Light-House Establishment maintains a fourth-order flashing coast light south of the entrance, and a harbor light, fog signal, and range light on the south pier. There is a life-saving station near the inner end of the north pier.

Original estimated cost of the work, 1866, amended in 1880, 1890, and 1892	$804,366.15
Whole amount expended to June 30, 1898	738,767.73

Money statement.

July 1, 1897, balance unexpended	$32,100.38
June 30, 1898, amount expended during fiscal year	11,501.96
July 1, 1898, balance unexpended	20,598.42
July 1, 1898, outstanding liabilities	155.40
July 1, 1898, balance available	20,443.02
Amount (estimated) required for completion of existing project	45,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	35,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving harbor of Grand Haven, Mich.

August 30, 1852 (mouth of Grand River)	$2,000.00	March 3, 1879	$9,000.00
June 23, 1866	65,000.00	June 14, 1880	50,000.00
March 2, 1867 (mouth of Grand River)	40,000.00	March 3, 1881	50,000.00
April 10, 1869 (allotment)	1,866.15	August 2, 1882	40,000.00
July 11, 1870	10,000.00	July 5, 1884	50,000.00
1870 (allotment)	500.00	August 5, 1886	30,000.00
March 3, 1871	6,000.00	August 11, 1888	25,000.00
June 10, 1872	15,000.00	September 19, 1890	75,000.00
March 3, 1873	75,000.00	July 13, 1892	90,000.00
June 23, 1874	50,000.00	August 18, 1894	25,000.00
August 14, 1876	15,000.00	June 3, 1896	20,000.00
June 18, 1878	15,000.00	Total	759,366.15

CONTRACT IN FORCE FOR IMPROVING HARBOR AT GRAND HAVEN, MICH.

Green's Dredging Company, dredging, dated March 26, 1897, approved April 14, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898, approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, GRAND HAVEN HARBOR, MICHICAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	1,508	1,405,600	1893	761	613,425
1889	1,110	649,370	1894	641	504,609
1890	1,172	834,089	1895	574	482,833
1891	819	616,422	1896	883	727,209
1892	815	693,835	1897	1,151	1,018,805

Receipts and shipments by vessel, 1897.

[Compiled from statements furnished by the collector of customs and United States Inspector R. C. Duryea, Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick	300	Farm products	6,0[illegible]
Coal	1,000	Fruit	1,7[illegible]
Feed	18,983	Hides	11
Flour	25,569	Lime and cement	11
Grain	27,436	Lumber	1[illegible]
Hides	104	Merchandise, general	14,6[illegible]
Iron ore	20,402	Pig iron	2,0[illegible]
Lime and cement	20,848	Potatoes	1[illegible]
Lumber	4,196		
Merchandise, general	25,822		
Pig iron	15,309		
Wood	3,581		
Total	163,550	Total	25,[illegible]

K K 9.

IMPROVEMENT OF GRAND RIVER, MICHIGAN.

From 1881 to 1884 $50,000 were expended in excavating channels 4 feet in depth through the worst shoals in this river below Grand Rapids. Work on the improvement was then suspended until 1896, when Congress by the river and harbor act of June 3 adopted the project now in course of execution, the object of which is to obtain a through channel 10 feet deep from Grand Rapids, Mich., to the mouth of the river at Grand Haven, 40 miles distant. Operations were commenced May 26, 1897, and progress to June 30, 1897, is outlined in the last Annual Report (p. 2921).

Operations were continued throughout the past fiscal year, except from December 11, 1897, to April 9, 1898, during which period the river was frozen up and the plant was in winter quarters. The work done during the year consisted in dredging channels through nine of the worst bars on the river, at points between 11 and 22 miles below Grand Rapids. The aggregate length of channels dredged to a depth of 6 feet, with a bottom width of 30 feet, was 30,883 feet, the amount of material excavated being 147,170 cubic yards, making a total excavation since May 26, 1897, when the improvement was commenced, of 161,205 cubic yards. The work was done by a special plant fitted up and operated by the Government, at a cost of 12.7 cents per cubic yard of material removed. The following report, prepared by Mr. G. W. Bunker, assistant engineer in immediate charge of operations since their beginning, gives a detailed history of these operations:

General history.—Under authority of an act of Congress dated June 3, 1896, providing for a dredged channel between Grand Haven and Grand Rapids, with a center depth of 10 feet and a bottom width of 100 feet, work was begun May 26, 1897, at a point about 2,000 feet below the ferry at Eastmanville, or 20.8 miles below the foot of Ganoes Canal at Grand Rapids.

On June 30, 1897, the date of the last Annual Report, the work had progressed to a point 21.5 miles below the foot of Ganoes Canal, having completed a cut through what is known as the Eastmanville bar and reached about the middle of the County House bar. From this point dredging was continued down stream through the remainder of the County House bar and across Rice's bar to a point 22.6 miles below the foot of Ganoes Canal and about one-half mile above the mouth of Bass River.

On examination it was found that from this point to Grand Haven there existed a continuous channel with a minimum depth of 5 feet and a bottom width of 30 feet or over. These were the dimensions of the channel which it was proposed to make with the present appropriation. Therefore the dredge and outfit were moved upstream to the lower end of Deer Creek Bar, 19.5 miles below the foot of Ganoes Canal and 1 mile above Eastmanville. Dredging began here July 16. From this point the dredging continued upstream, passing through the following bars, viz.: Deer Creek, Trail Creek, Lamont, and the lower half of the Bridge Street Bar. (A detailed account of these bars will be found in an accompanying tabular statement.)

Bridge Street Ferry, about the middle of the Bridge Street Bar and 14.7 miles below Ganoes Canal, was reached November 29. At this time floating ice in the river prevented further work and it was decided to make a winter harbor for the plant, where it would be safe from the ice floes during the high-water season and where necessary repairs could be made in preparation for the coming season's work. The mouth of Sand Creek, 11.8 miles below Ganoes Canal, was chosen for the location of the winter harbor. After experiencing much difficulty in breaking through the ice fields between Bridge Street Ferry and Sand Creek, the dredge and outfit arrived safely at the latter place December 4. Work on the harbor was begun at once and was completed December 11.

All repairs were made before laying up, to avoid delays in the spring. The plant was laid up January 5, 1898, the crew discharged, and a watchman left in charge during the winter.

The work of fitting out was begun on the dredge March 28. Dredging was begun at the mouth of Sand Creek April 6, the dredge, working downstream, clearing out the bars between Sand Creek and Bridge Street Ferry, where work stopped November 29, 1897. This point was reached June 9, when the outfit was moved up to the mouth of Sand Creek again and the work of dredging upstream begun.

June 30, the end of the fiscal year, the dredge had reached a point 10.9 miles below the foot of Ganoes Canal and about 800 feet above Haires Landing.

Plant.—The plant in use on the river July 1, 1897, was as follows: (1) U. S. dipper dredge *Farquhar;* (2) U. S. sand conveyer *Sand Sucker* (a sand-pump dredge, constructed for this special work from old machinery on hand), with 12 pontoon pipe floats; (3) U. S. gasoline launch *Bertha S.;* (4) *Grand River Scow No. 1.* To the above was added, September 18, a new pine scow 20 by 50 by 3 feet high, which was designated *Grand River Scow No. 2.*

Repairs to plant.—All repairs except those made to the machinery, which required the appliances of a machine or boiler shop, have been made by the regular dredge crew.

Description of Sand Sucker.—The *Sand Sucker* consists of a pine scow 24 by 100 by 3 feet high with an open pocket (8 feet square at bottom) near the forward end. Into this pocket is fitted an iron hopper, which is surmounted by a heavy iron grillage used to exclude from the hopper any substance too large to pass through the sand pump. Through a hole in the rear of the hopper the suction pipe of a 12-inch centrifugal sand pump (mounted on the deck of the scow) is inserted.

The motive power running the pump consists of an ordinary 12 by 16 high pressure stationary engine, developing 43 horsepower, with one iron boiler (locomotive pattern) 13½ feet long by 4 feet diameter, which is allowed 80 pounds of steam. Power is transmitted from the engine to the pump by means of a Hill friction clutch and a 12-inch leather belt.

The 12-inch discharge pipe of the pump leaves the scow at right angles to its side, is supported and floated by a series of pontoons. It consists of pieces of wrought-iron pipe 34 feet long connected by flexible rubber sleeves or joints. The couplings between the pontoons are also flexible, making it easy to handle the pipe lines. The rear end of the scow is occupied by coal bunkers and a sleeping room for the crew.

Efficiency of the Sand Sucker.—The sand pump in use at the beginning of the fiscal year was of the Van Wie pattern and developed a capacity of about 40 cubic yards per hour. A few changes were made in the ordinary arrangement of suction head and check valves, and the capacity was doubled.

During the winter the pump was remodeled under my direction, making for it a new suction head and piston, with the result that the ordinary expense of repair was reduced to about one-quarter of what it used to be and the pump doubled its capacity.

Plant and methods of work.—The plan of work for the river has been one of dredging alone. The U. S. dipper dredge *Farquhar* has been employed in making a single cut with a depth of 6 feet and a bottom width of 30 feet through all bars having a channel depth of less than 5 feet. The material thus dredged has been conveyed to the spoil bank (on or as near as possible to the shore, and as far as possible from the cut) by means of the *Sand Sucker.*

When ready for work, the *Sand Sucker* is attached to the side of the dredge in such a position as to make it convenient for the dredge to deposit the material taken in its dipper on the iron grillage which surmounts the hopper. The greater portion of the material passes at once through the grillage into the hopper and is taken by the suction of the sand pump and discharged on the spoil bank 200 or 300 feet distant from the cut. That which still remains on the grillage is disintegrated and washed through by playing on it with a stream of water from a steam force pump, the Worthington pattern.

The sand pump will handle any material which can be passed through a 5-inch square opening.

Surveys.—A very complete topographical survey of the river from Grand Rapids to the mouth of Bass River (23½ miles) was made in 1891. The survey of 1889 furnished the latest soundings over the whole distance from Grand Rapids to Grand Haven, and the outlines of the river from the mouth of Bass River to Grand Haven. On examination it was found that the marks left by both of the surveys were in a state of decay, about one-half of them having already disappeared.

Only such surveying work has been done as was thought necessary to preserve previous surveys and carry on the work in hand intelligently. For the latter purpose soundings have been taken previous to dredging over the first 34 miles above Grand Rapids; also, after dredging, for the purpose of estimates and a study of the work. Water gauges have been set and observations of high water and other data made, all of which have been and are being platted.

Dredging on bars from the beginning of work, May 26, 1897, to June 30, 1898.

	Name of bar.	Distance from Grand Rapids.	Length of cut.	Material.	Amount dredged.	Date of beginning cut.	Date of completing cut.
		Miles.	*Feet.*		*Cu. yds.*		
1	Haires	11	893	Sand and logs	4,050	June 25, 1898	Not completed.
2	Sand Creek	12	4,622	Stone and clay, sand and logs.	14,750	Apr. 6, 1898 June 12, 1898	Apr. 16, 1898. June 24, 1898.
3	Lowing	13	2,219	Sand, gravel, logs	8,550	Apr. 18, 1898	Apr. 29, 1898.
4	Bridge Street	14–15	8,869	Sand and logs	41,450	Apr. 29, 1898 Nov. 2, 1897	June 9, 1898. Nov. 29, 1897.
5	Lamont	16–17	6,430	Silt, sand, logs	41,030	Sept. 2, 1897	Oct. 30, 1897.
6	Trail Creek	18	2,989	Sand, fine gravel, and shells.	12,000	Aug. 13, 1897	Sept. 1, 1897.
7	Deer Creek	19½	3,076	Sand and logs	17,470	July 16, 1897	Aug. 12, 1897.
8	Eastmanville	21	2,580	Fine gravel, shells, sand, clay, stone, and logs.	12,335	May 26, 1897	June 28, 1897.
9	County House	21½	1,645	Sand and logs	7,070	June 28, 1897	July 9, 1897.
10	Rices	22½	705	.....do	2,500	July 9, 1897	July 13, 1897.
	Total		34,028		161,205		

Division of expenditures for fiscal year ending June 30, 1898.

Farquhar	$5,421.66
Sand Sucker	5,201.94
Survey	2,505.41
Bertha S	1,160.43
Contingencies	3,372.98
Original cost of plant	1,032.79
Total	18,695.21

AMOUNT AND COST OF WORK FOR FISCAL YEAR ENDING JUNE 30, 1898.

Number of miles of river cleared, 12; depth of cut below low water, 6 feet; bottom width of cut, 30 feet; total length of cut, 30,883 feet; number of cubic yards moved, 147,170; total amount expended during the year, $18,695.21; cost per cubic yard dredged, 12.70 cents.

AMOUNT AND COST OF WORK FOR APRIL, MAY, AND JUNE, 1898.

Number of cubic yards moved (three months), 50,100; total amount expended (three months), $4,734.03; cost per cubic yard dredged, 9.45 cents.

Durability of the work.—The chief reason for the adoption of the plan of dredging alone was, that on examining the results of the dredging of 1881 to 1886, it was found that in the main the cuts of those dates were still extant and the banks of some of them were well defined after the floods and ice gorges of more than twelve years. There were only five places in the first 11½ miles below Grand Rapids over which dredging was done at that time, where the cut has been entirely filled by the effect of cross currents on the surface sand. The above reason was thought sufficient for the adoption of the plan of "dredging alone" until experience should show that some further means were necessary to maintain the work.

Owing to the fact the draft of the dredge would not permit its being taken above the bars, the work was begun in the lower reach of the river where the current and the consequent changing of the river bed is very slight at low stages. No opportunity was offered during the dredging season of 1897 to study the effect of a flood on the deep narrow cut which had been made. During March of 1898, however, that opportunity came. On March 16 the crest of the flood passed Grand Rapids, showing a rise of 13.9 feet above the low-water stage and carrying away the ice gorges which had formed at various points along the river. This office has only one record of higher water, viz, that of 1893, which reached a point 16.2 feet above the low-water stage at Grand Rapids.

As soon as the water subsided sufficiently, soundings were taken over the cuts of 1897, at intervals of 600 feet, to ascertain the amount of fill resulting from the ice jams and flood. When platted, these soundings showed a result not wholly satisfactory. In some places the cut had entirely filled, while in others it could be plainly traced but was much wider than when completed and scarcely half as deep. Where

the filling had taken place the material through which the cut was made was a very fine sand, running like quicksand.

The general depth of the water over the bars, where cuts were made, was found to be from 0.5 to 1.5 feet greater than before dredging. This left a channel of not less than 4 feet between Bridge Street Ferry and Bass River, with the exceptions of possibly three or four places, the worst of which is on Deer Creek Bar, where an available depth of 2.5 is found.

The cross-sections of the river bed showed that the spoil banks had been affected by the flood much as the cuts had. Where the material was of a heavy gravelly nature, the banks were still traceable; but, where it was light, they had been leveled down and scarcely a trace of them could be found.

In the following table, possibly, there is a reason for the difference found in the durability of the cuts above and below the 12-mile mark:

Location.	Fall in river at low water.	Approximate mean distance between banks.	Nature of material in river bed.
	Feet.	*Feet.*	
From Grand Rapids to the 12-mile mark.	5.2	350	Bowlders, gravel, clay, and sand. (Obstructed by 7 islands.)
From the 12-mile mark to Lake Michigan.	1.0	600	Sand, fine gravel, shells, very little clay and bowlders. (No obstruction.)

The inference to be drawn is that in the first 12 miles the current is swift enough, in consequence of the closeness of the banks and the contraction occasioned by the islands, to partially maintain the cuts which are dredged, while in the stretch below the 12-mile mark no such favorable natural conditions exist.

The total amount expended to June 30, 1898, was $27,115.23, of which $18,695.21 were spent during the past fiscal year.

Whole amount appropriated and expended, 1881 to 1884, inclusive	$50,000.00
Original estimated cost of project adopted in 1896	670,500.00
Whole amount expended on present project to June 30, 1898	27,115.23

Money statement.

July 1, 1897, balance unexpended	$41,579.98
June 30, 1898, amount expended during fiscal year	18,695.21
July 1, 1898, balance unexpended	22,884.77
July 1, 1898, outstanding liabilities	1,609.13
July 1, 1898, balance available	21,275.64
Amount (estimated) required for completion of existing project	620,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	250,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving Grand River, Michigan.

March 3, 1881	$10,000
August 2, 1882	15,000
July 5, 1884	25,000
June 3, 1896	50,000
Total	100,000

COMMERCIAL STATISTICS, GRAND RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year—	Number.	Tonnage.
1896	282	46,750
1897	77	30,390

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by United States Inspector R. C. Duryea, Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Pig iron	19,402	Fruit	202
Shingles	63	Pig iron	872
		Wood	3,000
Total	19,465	Total	4,074

K K 10.

IMPROVEMENT OF MUSKEGON HARBOR, MICHIGAN.

The improvement of this harbor was commenced in 1867, and operations since then are outlined in the Report of the Chief of Engineers, United States Army, for the fiscal year ending June 30, 1897 (page 2923), the extent of pier work and general condition of the harbor at that time being as follows: The north pier and revetment, comprising 1,403 feet of crib work and 1,176 feet of pile work, had a total length of 2,579 feet and projected 1,213 feet beyond the shore line. The south pier and revetment, comprising 1,105 feet of crib work and 380 feet of pile work, had a total length of 1,485 feet and projected 1,415 feet beyond the shore line. The available depth through a narrow channel was 15 feet.

Operations during the last fiscal year comprised (1) the construction of 200 linear feet of crib work for extending the south pier; (2) repairing about 250 feet of old crib work of the same pier; and (3) dredging. These operations are more fully described in the following extract from the report of Mr. F. W. Lehnartz, assistant engineer in local charge:

The dredging operations commenced June 10, 1897, were still in progress at the beginning of the fiscal year. They were completed July 2. During this time an area 140 feet wide and averaging 940 feet in length was dredged to a depth of 20 feet below zero of gauge, through the shoal reach between the piers outside of the shore line. The amount dredged July 1 and 2 was 2,521 cubic yards, and the total amount since June 10, 20,102 cubic yards. As a result of this work there existed a continuous channel from Lake Michigan to Muskegon Lake not less than 16 feet deep, at the beginning of the fiscal year.

At the beginning of the fiscal year a contract was in force with Robert B. Rice for an extension of 200 feet to the south pier. This work was completed in October and consisted of two cribs, each 100 by 30 by 22½ feet, with a continuous superstructure 6 feet high filled with stone and decked over. The cribs rest on a foundation of piles, and a stone riprap was placed around the outer 50 feet of the end crib. The level of the bottom of the cribs is 23 feet below and that of the top of the superstructure is 6 feet above zero of gauge. Mooring posts were built into the work at distances of 50 feet.

The submerged part of the old crib work between station 3+80 and 6+29 was unsafe. Parts of the side walls had dropped out, and the temporary patching put upon it did not promise any lasting results. It was therefore deemed best to make

reliable repairs by building a wall of substantial sheet piling along the channel wall, and a contract was entered into with Adolph Green for this purpose under date of April 9, 1898. The work is to consist of triple sheet piling of 3 by 12 inch by 26 feet white-pine planks, protected on the front by white-oak piles 4 feet between centers and 34 feet long in the work, and by an oak wale, and secured to the front wall of the existing superstructure by screw bolts and to the rear wall by iron tie-rods. The top of the sheet piles is to be 2 feet and that of the round piles 4 feet above zero of gauge.

Operations under this contract were commenced May 18, and at the end of the fiscal year the sheet piles and part of the round piles were in place.

The total amount expended for improving the harbor to June 30, 1898, was $454,732.21, of which $24,390.31 were spent during the last fiscal year.

The approved project of improvement calls for extending the north pier 550 feet and the south pier 300 feet, and the commercial interests of the harbor require these extensions as soon as practicable. For maintaining the old pier work and required channel depth considerable repairs and dredging are required. The estimate for 1900 is therefore as follows: For 850 feet of pier extension, $102,000; repairing and refilling piers and revetments, $5,000; dredging, $5,000; making in all, with due allowance for supervision, engineering, and office contingencies, $120,000.

The harbor is in the Grand Haven collection district and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a fourth-order coast light on the south shore and a harbor light, fog bell, and range lights on the south pier. There is a life-saving station near the inner end of the north pier.

Original estimated cost of work, 1866, amended in 1869, 1873, 1881, 1884, 1890, and 1892	$589,000.00
Whole amount expended to June 30, 1898	454,732.21

Money statement.

July 1, 1897, balance unexpended		$33,658.10
June 30, 1898, amount expended during fiscal year		24,390.31
July 1, 1898, balance unexpended		9,267.79
July 1, 1898, outstanding liabilities	$155.32	
July 1, 1898, amount covered by uncompleted contracts	6,797.11	
		6,952.43
July 1, 1898, balance available		2,315.36

Amount (estimated) required for completion of existing project	125,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	120,000.00
Submitted in compliance with reqirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving harbor at Muskegon, Mich.

March 2, 1867	$59,000	August 2, 1882	$25,000
July 11, 1870	10,000	July 5, 1884	20,000
March 3, 1871	15,000	August 5, 1886	12,500
June 10, 1872	10,000	August 11, 1888	45,000
June 23, 1874	10,000	September 19, 1890	50,000
March 3, 1875	25,000	July 13, 1892	75,000
August 14, 1876	15,000	August 18, 1894	30,000
March 3, 1879	5,000	June 3, 1896	30,000
June 14, 1880	7,500		
March 3, 1881	20,000	Total	464,000

Abstract of bids for repairing Government pier at Muskegon, Mich., received and opened March 21, 1898, in accordance with advertisement dated February 19, 1898.

No. of bid.	Name and address of bidder.	To furnish following material and secure it in place.									Approximate total.
		White oak round piles (2,108 linear feet) per linear foot.	White oak timber (2,750 feet B. M.) per M feet B. M.	White pine timber (5,940 feet B. M.) per M feet B. M.	White pine plank for sheet piles (57,798 feet B. M.) per M feet B. M.	White pine plank for decking (11,504 feet B. M.) per M feet B. M.	Drift bolts (472 pounds) per pound.	Screw bolts (1,350 pounds) per pound.	Tie rods (3,500 pounds) per pound.	Spikes (1,595 pounds), per pound.	
a1	Adolph Green, Green Bay, Wis	*Cents.* 29	$36.00	$21.00	$26.50	$20.00	*Cents.* 2	*Cents.* 3	*Cents.* 2½	*Cents.* 2½	$2,797.11
2	John M. Allmendinger, Benton Harbor, Mich.	30	32.00	20.00	30.00	20.00	2	3	3	2½	3,017.05
b3	Love & West, Muskegon, Mich	30	35.00	21.00	36.00	19.00	2½	2½	2½	2½	3,345.72
4	William McIvor, Marseilles, Ill	32	36.50	28.50	35.50	18.25	2½	3	4	2½	3,460.47

a Contract entered into April 9, 1898.
b Guarantors' signatures not witnessed; certificate not executed.

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT MUSKEGON, MICHIGAN.

Green's Dredging Company, dredging, dated March 26, 1897; approved April 14, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

Robert B. Rice, pier work, dated May 27, 1897; approved June 11, 1897; date of beginning, June 1, 1897; date of expiration, November 1, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

Adolph Green, pier work, dated April 9, 1898; approved April 23, 1898; date of beginning, May 1, 1898; date of expiration, September 1, 1898.

COMMERCIAL STATISTICS, MUSKEGON HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	2,683	.....	1893	2,482	834,049
1889	4,626	884,869	1894	1,423	793,184
1890	3,786	649,540	1895	887	441,289
1891	2,886	704,046	1896	981	562,757
1892	4,174	740,021	1897	1,244	725,514

During the year a new car ferry line has been established between Muskegon and Milwaukee, Wis.

Receipts and shipments by vessel, 1897.

Articles received.	Tons.	Articles shipped.	Tons.
Coal	1,620	Feed	816
Flour	62,443	Fruit	6,699
Grain	2,239	Grain	259
Hay and feed	10,340	Leather	980
Lime and cement	6,489	Lime and cement	343
Lumber	62,291	Lumber	162,067
Merchandise, general	90,173	Merchandise, general	35,712
Miscellaneous	1,000	Miscellaneous	753
Paper	1,711	Pig iron	648
Pig iron	2,495	Potatoes	60
Salt	595	Salt	141
Stone and gravel	4,110	Slabs	7,022
Tan bark	216	Wood	3,233
Total	245,721	Total	278,733

K K 11.

IMPROVEMENT OF WHITE LAKE HARBOR, MICHIGAN.

Before improvement by the Government a narrow and crooked outlet from White Lake to Lake Michigan had been improved by local enterprise so as to permit vessels drawing about 5 feet to pass; but when the improvement by the Government was commenced, this channel was abandoned, and a straight cut dredged from lake to lake and covered by lateral revetments and piers. This work was in progress until 1882, by which time 3,959 feet of pile and crib work had been placed, of which 2,294 feet was on the north and 1,665 feet on the south side of the channel. No extensions have been made since 1882, but in the meantime 424 feet of revetment has washed away from the White Lake end on the south side and 166 feet from the north side.

No work was done at this harbor during the last fiscal year, and the harbor works at its close were therefore substantially in the same condition as at the beginning, viz, North pier, all pile work, was 1,515 feet long and projected 360 feet beyond the shore line; south pier, comprising 1,498 feet of pile work and 356 feet of crib work, had a total length of 1,854 feet, and projected 700 feet beyond the shore line. The north pier is in fair condition, except at its outer end. The south pier is generally in bad condition, and some portions of it are so dilapidated that they are liable to be carried away unless promptly rebuilt. The available channel depth between piers was 10½ feet.

The total amount expended for improving this harbor to June 30, 1898, was $280,604.08, of which $243.82 were spent during the past fiscal year.

The above project of improvement calls for a navigable depth of 12 feet through the channel between the piers, but that depth can not be maintained until extensions of about 450 and 250 feet are made to the north and south piers, respectively. The last approved plan of operations provides for extensions of 250 and 200 feet. Both old piers need considerable additional filling, and the south pier is in urgent need of extensive repairs.

The estimate for 1900 is as follows: Pier extensions, 450 feet, $45,000; for additional filling and general repairs of old piers, $10,000; dredging, $3,000; making in all, with due allowance for supervision, engineering, and office contingencies, $64,000.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a fourth-order flashing coast light on the south shore of the harbor, and a harbor light on the outer end of the south pier. There is a life-saving station near the inner end of north pier.

Original estimated cost of work, 1866, amended in 1873, 1884, and 1892.. $337,550.00
Whole amount expended to June 30, 1898..... 280,604.08

Money statement.

July 1, 1897, balance unexpended		$9,189.74
June 30, 1898, amount expended during fiscal year		243.82
July 1, 1898, balance unexpended		8,945.92
July 1, 1898, outstanding liabilities	$105.60	
July 1, 1898, amount covered by uncompleted contracts	2,000.00	
		2,105.60
July 1, 1898, balance available		6,840.32
Amount (estimated) required for completion of existing project		48,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		64,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations for improving harbor at White Lake, Mich.

March 2, 1867	$57,000	March 3, 1881	$7,500
April 10, 1869 (allotment)	44,550	August 2, 1882	12,000
July 11, 1870	20,000	July 5, 1884	10,000
March 3, 1871	20,000	August 5, 1886	10,000
June 10, 1872	10,000	August 11, 1888	10,000
March 3, 1873	7,000	September 19, 1890	17,000
June 23, 1874	10,000	July 13, 1892	5,000
March 3, 1875	10,000	August 18, 1894	5,000
August 14, 1876	5,000	June 3, 1896	5,000
June 18, 1878	12,000		
March 3, 1879	7,500	Total	289,550
June 14, 1880	5,000		

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT WHITE RIVER, MICHIGAN.

Green's Dredging Company, dredging, dated March 26, 1897; approved April 14, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, WHITE RIVER HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	1,408	147,142	1893	260	1,052,026
1889	732	.....	1894	195	18,115
1890	579	62,276	1895	281	34,574
1891	405	47,135	1896	245	27,962
1892	392	58,950	1897	247	33,409

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Merchandise, general	79,928	Fruit	102
Pig iron	4,000	Hides and leather	153
Wood	600	Lumber	6,878
		Merchandise, general	68,961
		Potatoes	73
		Slabs and wood	5,534
Total	84,528	Total	81,701

K K 12.

IMPROVEMENT OF PENTWATER HARBOR, MICHIGAN.

The governmental improvement of this harbor was commenced in 1867, but before that time a narrow channel about 4 feet deep had been made by local action to connect Pentwater Lake with Lake Michigan. The project adopted by the Government was to increase the channel width and depth to 150 and 12 feet, respectively, and protect the channel by lateral piers extending into Lake Michigan. Work on this project has been in progress ever since, but the depth of 12 feet has not yet been obtained, except for short periods following dredging, the piers having never been long enough to maintain such a depth.

No work was done at this harbor during the last fiscal year until May 23, 1898, when operations were commenced under contract with Nelson J. Gaylord, of Ludington, Mich., for rebuilding about 440 feet in length of the north pier, as described in the following extract from the report of Mr. F. W. Lehnartz, assistant engineer in local charge:

It is proposed to cut this work down to zero of gauge, drive a row of new white oak piles, 4 feet between centers and 26 feet long in the work, with the top at zero of gauge, along the front wall, and a wall of triple sheet piles of 2 inches by 12 inches by 10 feet white pine plank along the rear wall, connecting them at the top with the old structure by means of screw bolts and tie rods, and to build a new five-course superstructure on top. Work under this contract commenced May 23, and at the close of the fiscal year the old timber and filling above water had been removed, the old piles sawed off at grade, the old front piles capped with a 12 by 12 inch timber, the guides for the sheet piles put in place, and 51 linear feet of the wall of triple sheet piles driven along the rear wall.

The condition of the harbor June 30, 1898, was as follows: The north pier, consisting of 1,824 feet of pile work and 402 feet of crib work, had a total length of 2,226 feet and projected 610 feet beyond the shore line. The south pier, comprising 1,126 feet of pile work and 721 feet of crib work, had a total length of 1,847 feet and projected 621 feet beyond the shore line. Both piers are in need of extensive repairs, amounting in part to a practical reconstruction, nearly 2,000 feet of their length being more than twenty years old, and one-half of that length approximating thirty years. The maximum available depth at shoalest part of channel June 30, 1898, was 10½ feet. The total expenditure on this harbor to June 30, 1898, was $241,668.31, of which $403.35 were spent during the last fiscal year.

The piers reach to but little beyond the 10-foot curve in Lake Michigan, and for this reason a greater navigable depth can not be kept except as dredging serves to give it temporarily. Twelve feet, as called for by the approved project, can be obtained and held with any reasonable permanence only when the piers shall have been extended to the 15-foot curve, now from 300 to 400 feet distant. The limit of extension at present authorized is 200 feet for the south and nothing for the north pier. The old portions of both piers must be rebuilt above water.

The estimate for 1900 is as follows: For extending the south pier 200 feet, $20,000; rebuilding 1,800 feet of old piers, $21,600; dredging, $4,000; making in all, with due allowance for supervision, engineering, and office contingencies, $50,000.

This harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a harbor light near the outer end of south pier. There is a life-saving station near the inner end of north pier.

Original estimated cost of improvement, 1867 ..... $327,713.40
Whole amount expended to June 30, 1898 ..... 241,668.31

Money statement.

July 1, 1897, balance unexpended		$7,555.04
June 30, 1898, amount expended during fiscal year		403.35
July 1, 1898, balance unexpended		7,151.69
July 1, 1898, outstanding liabilities	$708.57	
July 1, 1898, amount covered by uncompleted contracts	4,474.72	
		5,183.29
July 1, 1898, balance available		1,968.40
Amount (estimated) required for completion of existing project		78,893.40
Amount that can be profitably expended in fiscal year ending June 30, 1900		50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June, 4, 1897.		

Appropriations for improving harbor at Pentwater, Mich.

March 2, 1867	$55,000	August 2, 1882	$10,000
April 10, 1869 (allotment)	17,820	July 5, 1884	15,000
July 11, 1870	10,000	August 5, 1886	10,000
March 3, 1871	10,000	August 11, 1888	8,000
June 10, 1872	30,000	September 19, 1890	8,000
March 3, 1873	20,000	July 13, 1892	5,000
August 14, 1876	10,000	August 18, 1894	5,000
June 18, 1878	10,000	June 3, 1896	5,000
March 3, 1879	6,000		
June 14, 1880	4,000	Total	248,820
March 3, 1881	10,000		

Abstract of bids for repairing Government pier at Pentwater, Mich., received and opened March 21, 1898, in accordance with advertisement dated February 19, 1898.

No. of bid.	Name and address of bidder.	1.—To cut down and remove old work, etc. (428 linear feet), per linear foot.	2.—To furnish following material and secure it in place. White oak round piles (2,782 linear feet), per linear foot.	White oak timber (4,730 feet B. M.), per M feet B. M.	White pine timber (78,624 feet B. M.), per M feet B. M.	White pine plank for sheet piles (25,380 feet B. M.), per M feet B. M.	White pine plank for decking (3,888 feet B. M.), per M feet B. M.	Driftbolts (12,992 pounds), per pound.	Screw bolts (6,089 pounds), per pound.	Tie rods (4,158 pounds), per pound.	Spikes (561 pounds), per pound.	Angle irons (5,616 pounds), per pound.	Approximate total.
								Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	
a1	Nelson J. Gaylord, Ludington, Mich	$0.60	$0.28	$32.00	$19.50	$25.00	$18.00	2	2	2	2	2	$4,020.59
2	Robert B. Rice, Muskegon, Mich	.50	.29	40.00	20.00	35.00	15.00	2	2⅛	2⅛	3	2⅛	4,412.83
3	William Brownrigg, Manistee, Mich	.77	.32½	38.00	20.55	32.15	17.00	2¼	2¼	2¼	2¼	2¼	4,582.74
4	Lynch & Weimer, Ludington, Mich	1.00	.28	40.00	21.50	28.00	18.00	2⅛	2 3/16	2 7/16	3	3	4,672.62
b5	Love & West, Muskegon, Mich	1.25	.28	32.00	18.00	47.00	17.00	2	2	2	2	2	4,741.93
6	William McIvor, Marseilles, Ill	1.75	.29	30.50	20.75	30.75	18.50	2¼	2¼	2¼	2¼	2¼	4,854.94
7	Adolph Green, Greenbay, Wis	1.95	.31	36.00	20.75	26.50	19.00	2	3	2⅛	3	5	5,097.23
8	John M. Allmendinger, Benton Harbor, Mich	1.50	.28	32.00	22.00	40.00	20.00	2	3	3	2½	4	5,211.52

a Contract entered into Apr. 9, 1898.
b Guarantors' signatures not witnessed; certificate not executed.

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT PENTWATER, MICH.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897; approved, April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898; date of approval, April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

Nelson J. Gaylord, pier work, dated April 9, 1898; approved, April 22, 1898; date of beginning, May 1, 1898; date of expiration, September 1, 1898.

COMMERCIAL STATISTICS, PENTWATER HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	300	45,000	1893	116	.....
1889 *a*	.....	.....	1894	60	.....
1890	27	2,559	1895	500	.....
1891	1,140	71,260	1896 *a*	.....	.....
1892 *a*	.....	.....	1897 *a*	.....	.....

a Not stated.

Two new lines of transportation, one to Chicago and one to Sheboygan, Wis., were established during the year.

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by Fred Neilsen, village president.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick	100	Fish	13
Coal	100	Fruit	756
Grain	460	Furniture	930
Gravel	200	Lumber	17,000
Hay and feed	115	Potatoes	111
Merchandise	657	Posts and ties	3,010
Miscellaneous	313	Tan bark	2,000
		Wood and slabs	5,000
Total	1,945	Total	28,820

K K 13.

IMPROVEMENT OF LUDINGTON HARBOR, MICHIGAN.

The Government part in the development of this harbor dates from 1867, when private enterprise had made and for some years maintained a narrow channel with a depth of 7 feet from Lake Michigan to Pere Marquette Lake. Operations from that time to June 30, 1897, are outlined in the last Annual Report (page 2930), the extent of pier work and general condition of the harbor at that time being as follows: The north pier had a total length of 1,452 feet, and projected into Lake Michigan 880 feet beyond the shore line; the south pier, comprising 567 feet of pile work and 1,814 feet of crib work, had a total length of 2,381 feet, and projected 1,435 feet beyond the shore line. The available channel depth was 16½ feet.

Operations during the last fiscal year consisted in rebuilding sections of the old piers, aggregating 510 feet in length, as described in the fol-

lowing extract from the report of Mr. F. W. Lehnartz, assistant engineer in local charge:

Contractor William Brownrigg continued the work of reconstructing parts of the two piers near shore line, which was commenced in the previous fiscal year, and completed the same September 27, 1897.

This work consisted in cutting down to zero of gauge the old timber work above water, driving a row of triple sheet piles of 3 by 12 inches by 26 feet white-pine plank on the channel side, protected by a row of white-oak piles, 4 feet between centers and 33 feet long, in the work, and connecting the same at the top by means of binding timbers, wales, screw bolts, and tie-rods to the remaining old structure. The top of the piles and sheet piles is at the level of zero of gauge. A new superstructure 6 feet high, and resting in front on the new round piles and in the rear on the old rear wall, was put on top, the pier was refilled with the stone saved from the old work, and a plank walk 3 feet wide was laid on the new structure. The part of the north pier thus rebuilt extends from station 10+32 to 12+39, 207 linear feet, and the rebuilt part of the south pier from station 8+70 to 11+73, 303 linear feet.

The total amount expended in improving the harbor to June 30, 1898, was $380,879.56, of which $12,059.66 were spent during the last fiscal year. The maximum available depth of the shoalest part of the channel June 30, 1898, was 16½ feet.

A special report in relation to this harbor, dated January 2, 1897, was submitted to Congress in compliance with the provisions of the river and harbor act of June 3, 1896, and published as House Ex. Doc. No. 273, Fifty-fourth Congress, second session. The estimate was as follows:

Extension of north pier 700 feet, at $120 per foot	$84,000
Extension of south pier 300 feet, at $150 per foot	45,000
Dredging 60,000 cubic yards, at 15 cents per cubic yard	9,000
Reconstruction of 1,600 feet piers, at $25 per foot	40,000
Repairs to pile revetment of south pier, 567 feet, at $20 per foot	11,340
Minor repairs to remaining piers	1,660
	191,000
Ten per cent for contingencies	19,000
Total	210,000

The estimate under the present approved project for 1900 is for rebuilding 1,760 feet of old piers, $35,000; dredging and minor repairs, $6,000; making, in all, with due allowance for engineering, supervision, and office contingencies, $45,000.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The light-house establishment maintains a harbor light and fog whistle near the end of south pier. There is a life-saving station near the inner end of north pier.

Original estimated cost of work, 1867	$270,682.00
Estimated cost of enlarged project of 1890	111,000.00
Total	381,682.00
Whole amount expended to June 30, 1898	380,879.56

Money statement.

July 1, 1897, balance unexpended		$19,614.20
June 30, 1898, amount expended during fiscal year		12,059.66
July 1, 1898, balance unexpended		7,554.54
July 1, 1898, outstanding liabilities	$54.55	
July 1, 1898, amount covered by uncompleted contracts	4,000.00	
		4,054.55
July 1, 1898, balance available		3,499.99
Amount that can be profitably expended in fiscal year ending June 30, 1900		45,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867, and of sundry civil act of June 4, 1897.

Appropriations for improving harbor at Ludington, Mich.

March 2, 1867	$50,000.00	August 2, 1882	$12,000.00
April 10, 1869 (allotment)	31,185.00	July 5, 1884	10,000.00
July 11, 1870	10,000.00	August 5, 1886	56,250.00
March 3, 1871	10,000.00	August 11, 1888	60,000.00
June 10, 1872	10,000.00	July 13, 1892	5,000.00
March 3, 1873	25,000.00	August 18, 1894	6,000.00
June 23, 1874	20,000.00	June 3, 1896	25,000.00
March 3, 1875	10,000.00		
August 14, 1876	10,000.00	Total	388,435.00
June 18, 1878	15,000.00	Amount carried to the surplus fund, 1872	.90
March 3, 1879	5,000.00		
June 14, 1880	8,000.00		388,434.10
March 3, 1881	10,000.00		

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT LUDINGTON, MICH.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897; approved April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William Browning, pier work, dated March 26, 1897; approved April 9, 1897; date of beginning, April 15, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, LUDINGTON HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	1,778	277,074	1893	979	211,435
1889	1,759	.....	1894	1,466	426,599
1890	2,270	461,997	1895	1,556	594,124
1891	2,420	610,057	1896	1,996	952,469
1892	1,969	538,568	1897	2,063	2,944,425

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Coal	1,468	Bark	7,498
Feed	40,583	Brick	79,678
Flour	225,014	Coal	34,871
Grain	63,568	Hides	2,196
Hides	924	Lumber	112,515
Lime and cement	24,226	Merchandise, general	49,293
Lumber	47,596	Miscellaneous	1,277
Merchandise, general	47,451	Pig iron	33,163
Miscellaneous	774	Potatoes	441
Pig iron	3,256	Salt	176,813
Total	454,860	Total	497,744

K K 14.

IMPROVEMENT OF MANISTEE HARBOR, MICHIGAN.

The improvement of this harbor by the Government has been in progress since 1867, and the last Annual Report outlines the operations to June 30, 1897 (pp. 2933–2934). The conditions existing at that time were as follows: The north pier, comprising 1,304 feet of pile work and 1,602 feet of crib work, had a total length of 2,906 feet, and projected 1,230 feet beyond the shore line; the south pier, all crib work, was 1,200 feet long, and projected 665 feet beyond the shore line.

Operations during the last fiscal year were limited to dredging, the work being done between July 13 and 31, 1897, by the Green Bay Dredge and Pile Driving Company, under contract dated March 26, 1897. The amount excavated was 11,664 cubic yards, and resulted in increasing the channel depth at the shoalest points from 13½ to 15 feet.

The total amount expended for improving the harbor June 30, 1898, was $361,858.32, of which $1,856.50 were spent during the past fiscal year. The maximum available depth at the shoalest part of the channel June 30, 1898, was 14 feet.

The approved project of improvement calls for the addition of 350 feet to the south pier, and this should be made as soon as possible, as it is impracticable, under the present condition of affairs, to maintain the required channel depth. In addition to some minor repairs, 300 linear feet of crib work, over twenty years old, is so badly decayed that it should be entirely rebuilt above water. Dredging is required annually for restoring the navigable depth.

The estimate for 1900 is therefore as follows: For extending the south pier 350 feet to complete the present project, $42,000; rebuilding 300 feet of old pier above water, $3,600; minor repairs and dredging, $5,000; making in all, with due allowance for supervision, engineering, and office contingencies, $55,000.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The light-house establishment maintains a coast light on the shore north of the harbor and a pierhead light and fog whistle near end of north pier. There is a life-saving station near inner end of north pier.

Original estimated cost of the work, 1866, amended in 1871, 1875, 1890, and 1892	$408,000.00
Whole amount expended to June 30, 1898	361,858.32

Money statement.

July 1, 1897, balance unexpended		$14,998.18
June 30, 1898, amount expended during fiscal year		1,856.50
July 1, 1898, balance unexpended		13,141.68
July 1, 1898, outstanding liabilities	$53.80	
July 1, 1898, amount covered by uncompleted contracts	3,000.00	
		3,053.80
July 1, 1898, balance available		10,087.88

Amount (estimated) required for completion of existing project	50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	55,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving harbor at Manistee, Mich.

March 2, 1867	$60,000	March 3, 1881	$10,000
July 11, 1870	20,000	August 2, 1882	15,000
March 3, 1871	9,000	July 5, 1884	10,000
June 10, 1872	10,000	August 5, 1886	10,000
March 3, 1873	10,000	August 11, 1888	10,000
June 23, 1874	10,000	September 19, 1890	50,000
March 3, 1875	25,000	July 13, 1892	50,000
August 14, 1876	14,000	August 18, 1894	12,000
June 18, 1878	15,000	June 3, 1896	15,000
March 3, 1879	10,000		
June 14, 1880	10,000	Total	375,000

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT MANISTEE, MICH.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897; approved April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

COMMERCIAL STATISTICS, MANISTEE HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	3,595	966,221	1893	2,831	959,550
1889	3,524	945,329	1894	3,064	956,463
1890	3,691	975,049	1895	3,054	930,645
1891	3,617	1,079,818	1896	2,355	642,948
1892	4,044	1,028,629	1897	2,371	666,009

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick	1,475	Bark	9,503
Coal	2,554	Fruit	111
Flour	4,983	Lumber	538,913
Grain	3,623	Merchandise, general	2,883
Hay and feed	3,623	Piles	462
Logs	1,100	Potatoes	375
Merchandise, general	6,297	Salt	196,627
Miscellaneous	186	Staves	363
Stone	340	Wood	2,439
Total	24,542	Total	551,066

K K 15.

HARBOR OF REFUGE AT PORTAGE LAKE, MANISTEE COUNTY, MICHIGAN.

The improvements at this place by the Government were commenced in 1879, with a view to making a harbor of refuge for general commerce, and the progress of the work to June 30, 1897, is outlined in the last Annual Report (page 2936).

Operations during the last fiscal year consisted in dredging 18,019 cubic yards of sand from the channel way between piers; rebuilding

en the piers, and the same depth on the outer bar.
he beginning of the fiscal year a contract was in force with Nelson J. Gay-
lated May 22, 1897, for the reconstruction of the south pier from station 7+70
outer end. The operations consisted in cutting the old work down to grade,
g a wall of triple sheet piles along the front and 48 linear feet of the rear
with cross walls at the outer end and connecting the inner end of the rear
piling with the front wall, protecting the sheet piling with a row of round
and building a 6-course superstructure on top. The triple sheet piles con-
3 by 12 inch by 24 feet white pine planks in the front and outer end walls,
3 by 12 inch by 18 feet white pine planks in the rear and interior cross walls.
ound piles are of white oak and 30 feet long in the work. The top of the sheet
nd round piles in the side walls is at the level of zero of gauge and in the
walls at 0.5 feet above zero. The sheet piles are secured at the top by means
by 12 inch binding timber and screw bolts, and the round piles are tied to the
with an outer wale, screw bolts, and tie-rods. The superstructure is 6 feet
its front wall, outer end wall, and the part over the sheet-piled portion of the
all rest on the new oak piles, the remainder of the rear wall on the old rear
The cross ties are 8 feet apart, center to center. The part of the pier
ed by sheet piles, at the outer end, was filled with sand to 1 foot below zero,
ith stone on the sand to the top of the work, and it was decked with 3 by 12
hite pine plank. A plank walk 3 feet wide was laid on the remainder of
built work. The previously removed old edgings, as far as they were still
eable, were replaced in the pier, and 78 cords stone, furnished by the con-
r, were distributed on the same. The contractor furnished all the material with
ception of the 12 by 12 inch timber, which belonged to the United States, and
n hand at the harbor. The contract was completed November 30, 1897. In
quence of these repairs the south pier attained an additional length of 3 feet.
April 9, 1898, a contract was entered into with William Brownrigg for raising
perstructure of the pile work in the north pier 2 feet, and for refilling the
with stone. Operations were commenced May 19, and at the end of the fiscal
the timber work had been completed and about 162 cords stone had been
ed and distributed in parts of the piers. It will require about 340 cords stone
to complete the contract. The new timbers cover the entire pile work in the
pier, as well as in the wing at the east end.

e condition of the piers at the close of the fiscal year was as fol-
: North pier, comprising 1,342 linear feet of pile work and 151 feet
ib work, had a total length of 1,493 feet and projected 515 feet
nd the Lake Michigan shore line. As a result of the repairs made
ng the past two years this pier is now in good serviceable condition

they now end at the 10-foot curve. The work done during the past two years has simply restored the piers to the condition in which they were more than ten years ago, and unless they are now prolonged to deep water the whole expenditure of nearly $150,000 will have been useless as respects its essential purposes.

The estimate for 1900 is therefore as follows: For 1,600 linear feet of pier extension, $125,000; rebuilding 787 linear feet of south pier, $15,000; dredging, $5,000; making in all, with due allowance for supervision, engineering, and office contingencies, $155,000.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a harbor and range light near the outer end of north pier.

Original estimated cost of work, 1879, amended in 1890	$267,500.00
Whole amount expended to June 30, 1898	141,223.31

Money statement.

July 1, 1897, balance unexpended		$26,392.35
June 30, 1898, amount expended during fiscal year		17,115.66
July 1, 1898, balance unexpended		9,276.69
July 1, 1898, outstanding liabilities	$2,115.38	
July 1, 1898, amount covered by uncompleted contracts	3,803.97	
		5,919.35
July 1, 1898, balance available		3,357.34
Amount (estimated) required for completion of existing project		160,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		155,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for harbor of refuge at Portage Lake, Michigan.

March 3, 1879	$10,000	August 11, 1888	$10,000
June 14, 1880	10,000	September 19, 1890	8,000
March 3, 1881	10,000	August 18, 1894	25,000
August 2, 1882	25,000	June 3, 1896	25,000
July 5, 1884	12,500		
August 5, 1886	15,000	Total	150,500

Abstract of bids for repairing Government pier at Portage Lake, Michigan, received and opened March 21, 1898, in accordance with advertisement dated February 19, 1898.

No. of bid.	Name and address of bidder.	To furnish following material and secure it in place.					Approximate total.
		White-pine timber (92,062 feet B. M.), per M feet B. M.	Driftbolts (15,170 pounds), per pound.	Screw bolts (4,876 pounds), per pound.	Angle irons (8,240 pounds), per pound.	Stone filling (500 cords), per cord.	
			Cents.	Cents.	Cents.		
a1	William Brownrigg, Manistee, Mich	$18.75	1¾	2	2	$6.85	$4,952.21
2	Nelson J. Gaylord, Ludington, Mich	19.00	2¼	2¼	2¼	5.10	4,960.52
3	Z. L. Beauvais, Muskegon, Mich	19.50	2 1/16	2 1/16	2 1/16	5.40	5,286.88
4	Robert B. Rice, Muskegon, Mich	20.00	2	2¼	2¼	5.75	5,374.54
5	William McIvor, Marseilles, Ill	20.25	2¼	2¼	2¼	6.25	5,651.34
6	Adolph Green, Green Bay, Wis	21.00	2	3	5	5.65	5,662.58
7	Lynch & Weimer, Ludington, Mich	21.50	2¼	2 3/16	3	6.39	5,968.21
b8	Love & West, Muskegon, Mich	22.00	2¼	2¼	2¼	8.00	6,780.71

a Contract entered into April 9, 1898.
b Guarantors' signatures not witnessed; certificate not executed.

CONTRACTS IN FORCE FOR HARBOR OF REFUGE AT PORTAGE LAKE, MICHIGAN.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897; approved April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

Nelson J. Gaylord, pier work, dated May 22, 1897; approved June 3, 1897; date of beginning, June 1, 1897; date of expiration, November 1, 1897; extended to November 15, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

William Brownrigg, pier work, dated April 9, 1898; approved April 20, 1898; date of beginning, May 1, 1898; date of expiration, September 1, 1898.

COMMERCIAL STATISTICS.

No commercial statistics can be obtained.

K K 16.

IMPROVEMENT OF FRANKFORT HARBOR, MICHIGAN.

The improvements at this harbor, by the Government, were commenced under the river and harbor act of June 23, 1866, and operations to June 30, 1897, are outlined in the last Annual Report (p. 2939). The project now in course of execution was adopted by the river and harbor act of June 3, 1896, and its object is to provide and maintain a navigable channel depth of 18 feet.

Operations during the last fiscal year consisted in making some minor repairs to the old piers and in rebuilding two unserviceable sections, aggregating 966 feet in length, as described in the following extract from the report of Mr. F. W. Lehnarts, assistant engineer, in local charge:

Plans had been made during the previous fiscal year for rebuilding the superstructure of parts of the old piers, and on June 25, 1897, bids had been opened for doing the work. The lowest bidder was Nelson J. Gaylord, and contract was entered into with him July 2. Operations were commenced August 4, and the work was completed November 20. The parts of the two piers repaired were: North pier, station 3+95 to 8+47, 452 linear feet, and south pier, station 1+85 to 6+99, 514 linear feet. The old work was cut down to zero of gauge. A row of white-oak piles, 4 feet between centers and 32 feet long in the work, with the top at zero of gauge, was driven along the channel wall of the old work, and a new superstructure put on, the front wall resting on the new piles, and the rear wall on the old substructure. The superstructure is 5 feet high throughout in the front wall, but only 3 feet high in the rear wall from the inner end to near the shore line, and thence 5 feet high. The old stone filling was replaced in the work, and a walk 3 feet wide was placed on top.

A contract for repairing about 280 feet more of the old work in the south pier in a manner similar to that of last season was entered into with Robert B. Rice under date of April 9, 1898, but actual operations have not yet commenced. The contractor wishes to postpone this until the plant now in use by him on the repairs at Charlevoix Harbor becomes available.

Some broken timbers in the upper courses of the front wall of the south pier, between stations 0+60 and 0+88 and between stations 1+05 and 1+33, were cut out and replaced by new ones.

The condition of the harbor at the close of the year was as follows: North pier, comprising 395 linear feet of pile work and 1,104 feet of crib work, had a total length of 1,499 feet, and projected 700 feet beyond the shore line; south pier, comprising 186 feet of pile work and 1,752 feet of crib work, had a total length of 1,938 feet, and projected 1,460

feet beyond the shore line. The outer section of this pier, 400 feet length, was built by the Toledo and Ann Arbor Railway Company 1896–97, at its own expense, in order to expedite work under the new adopted project of improvement. The maximum available depth at t shoalest part of the channel June 30, 1898, was scant 16 feet, the wi of channel at that depth being less than 60 feet.

The amount expended on this harbor to June 30, 1898, was $333,413. of which $9,065.57 were spent during the past fiscal year.

The completion of the project now in course of execution requires t immediate extension of the north pier by 600 feet, to supplement th already made to the south pier at the expense of the railway compa and, besides some minor repairs to the old piers, two unserviceable s tions, aggregating 650 feet in length, must be rebuilt; dredging obtain the depth called for will also be required throughout the chan way between the piers.

The estimate for 1900 is, therefore, as follows: For extending the no pier 600 feet, $55,000; rebuilding 650 linear feet of old piers, $6,5 minor repairs of piers and dredging, $8,000; making in all, with a allowance for supervision, engineering, and office contingencies, $75,0

The harbor is in the Grand Haven collection district, and the nearest port of en is Grand Haven, Mich. The light-house establishment maintains a harbor light fog bell near the outer end of south pier. There is a life-saving station on the in end of south pier.

Original estimated cost of the work, 1866, amended in 1868, 1879, and 1892	$325, 65
Whole amount expended to June 30, 1898	333, 41

Money statement.

July 1, 1897, balance unexpended		$18, 5
June 30, 1898, amount expended during fiscal year		9, 0
July 1, 1898, balance unexpended		9, 1
July 1, 1898, outstanding liabilities	$36.00	
July 1, 1898, amount covered by uncompleted contracts	5, 846. 98	
		5,
July 1, 1898, balance available		3
Amount (estimated) required for completion of existing project		6
Amount that can be profitably expended in fiscal year ending June 30, 1900		7
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations for improving harbor at Frankfort, Mich.

Aux Becs Scies, Mich.:		Frankfort, Mich.:	
June 23, 1866	$88, 541. 00	August 2, 1882	
March 2, 1867	10, 000. 00	July 5, 1884	
July 25, 1868 (allotment)	10, 000. 00	August 5, 1886	
April 10, 1869 (allotment)	29, 318. 85	August 11, 1888	
July 11, 1870	10, 000. 00	September 19, 1890	
March 3, 1871	10, 000. 00	July 13, 1892	
[illegible] Mich.:		August 18, 1894	
[illegible]	10, 000. 00	June 3, 1896	

Abstract of bids for repairing Government pier at Frankfort, Mich., received and opened March 21, 1898, in accordance with advertisement dated February 19, 1898.

No. of bid.	Name and address of bidder.	1.—To cut down and remove old work, etc. (283 linear feet), per linear foot.	2.—To furnish following material and secure it in place.									Approximate total.
			White oak round piles (2,272 linear feet), per linear foot.	White oak timber (3,100 feet B. M.), per M feet B. M.	White pine timber (58,824 feet B. M.), per M feet B. M.	White pine plank (2,592 feet B. M.), per M feet B. M.	Driftbolts (6,853 pounds), per pound.	Screw bolts (3,342 pounds), per pound.	Tie-rods (3,412 pounds), per pound.	Spikes (104 pounds), per pound.	Angle irons (5,616 pounds), per pound.	
a1	Robert B. Rice, Muskegon, Mich	$1.15	$0.31½	$40.00	$20.00	$15.00	Cts. 2	Cts. 2½	Cts. 3	Cts. 3	Cts. 2½	$2,846.98
2	William McIvor, Marseilles, Ill	1.75	.29	31.50	20.50	18.25	2¼	2¼	2¼	2½	2½	2,989.83
3	Lynch & Weimer, Ludington, Mich	1.20	.28	40.00	21.50	18.00	2⅓	2 5/10	2 5/10	3	3	2,943.17
4	Nelson J. Gaylord, Ludington, Mich	1.50	.32	35.00	21.00	19.00	2	2½	2½	2½	2½	2,993.50
5	Adolph Green, Green Bay, Wis	1.95	.29	36.00	21.00	20.00	2	3	2½	3	5	3,216.01
6	John M. Allmendinger, Benton Harbor, Mich	1.50	.30	32.00	24.00	20.00	2	3	3	2½	4	3,235.58
b7	Love & West, Muskegon, Mich	1.75	.40	40.00	22.00	21.00	3	3	3	3	3	3,456.42

a Contract entered into April 9, 1898.
b Guarantors' signatures not witnessed; certificate not executed.

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT FRANKFORT, MICH.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897, approved April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

Nelson J. Gaylord, pier work, dated July 2, 1897, approved July 15, 1897; date of beginning, July 1, 1897; date of expiration, November 1, 1897; extended to November 15, 1897.

William A. Starke, dredging, dated April 9, 1898, approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

Robert B. Rice, pier work, dated April 9, 1898, approved April 20, 1898; date of beginning, May 1, 1898; date of expiration, September 1, 1898.

COMMERCIAL STATISTICS, FRANKFORT HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	1,342	216,376	1893	988	278,709
1889a			1894	1,101	337,728
1890	443	57,140	1895	1,182	412,951
1891	1,541	258,908	1896	1,374	509,277
1892	910	167,777	1897	1,714	706,546

a Not stated.

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by the collector of customs at Grand Haven, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Feed	9,111	Bark	14,511
Flour	15,259	Lumber	32,282
Grain	568	Merchandise, general	6,654
Lumber	123	Potatoes	81
Merchandise, general	306	Wood	503,450
Total	25,367	Total	556,450

In addition to the classified tonnage the car ferries between Frankfort, Mich., and Kewaunee, Wis., carried 16,639 freight cars, average weight 27,000 pounds, making 224,627 tons.

K K 17.

IMPROVEMENT OF CHARLEVOIX HARBOR, MICHIGAN.

The present commercial harbor at this place has been made by establishing a navigable channel from Lake Michigan to Round Lake. The natural outlet from the latter, called Pine River, was a narrow stream about one-third of a mile long, through which boats drawing 2 or 3 feet might pass. Local enterprise, aided by State land grant, improved these conditions by dredging the river to a depth of 11 feet and building short piers at its outlet into Lake Michigan, thereby obtaining an available depth at entrance of about 6 feet. At this point the work of improvement by the General Government was inaugurated with an appropriation of $10,000 in the river and harbor act of August 14, 1876. The project of improvement, submitted October 30, 1875, was the basis of operations, and provided for dredging a straight channel 12 feet deep through Pine River, protecting its sides by pile revetments, and its entrance by crib piers extending to 12 feet of water in Lake Michigan, with a channel way 150 feet wide between them. In 1882 this project was extended to provide a revetted channel 12 feet deep from Round Lake to Pine Lake. These projects have been duly completed, except as respects the south pier at the Lake Michigan entrance.

The condition of the harbor and extent of improvement June 30, 1896, were as follows:

Lower channel, from Lake Michigan to Round Lake.—North pier and revetments, comprising 780 feet of crib pier and 945 feet of pile revetment, had a total length of 1,725 feet, and ended in water 15 feet deep in Lake Michigan at a distance of 740 feet from its shore line. South pier and revetments, comprising 491 feet of crib pier and 1,539 feet of pile revetment, had a total length of 2,030 feet, and ended in water 11 feet deep at a distance of 370 feet from the shore line. Available depth of channel, 15 feet.

Upper Channel from Round to Pine Lake.—North revetment 339 and south revetment 366 feet long. At the beginning of the last fiscal year operations had been commenced under a contract with Jos. A. Beauvais, dated April 8, 1897, to repair the north pier from Station 9+45 to 14+23 by removing what remained above water of the old crib, and backing their submerged portion by a substantial mass of riprap stone, so disposed as to level about 6 feet above the water surface with a width

of 10 feet and have a slope of 1 on 2 on the exposed lake side; the facing of the exposed slope and top surface to be of stones weighing over 1,000 pounds each, and of the natural slope on the channel side over 300 pounds; the stone filling of the submerged cribs to be leveled at the water surface with top stones weighing at least 200 pounds. Operations were continued until December, 1897, when the work was completed and contract closed. The total amount of stone placed by the contractor was 1,036 cords. Another contract was entered into April 9, 1898, with Robert B. Rice, of Muskegon, Mich., for repairing 723 feet of the south revetment of the Lower Channel, from Station 4 to 11+23, by removing the parts of the old structure down to the water surface, reenforcing the front row of piles with additional ones where needed, driving a new row of rear piles, and placing a new superstructure rising 5 feet above water on the channel face. Operations under this contract were commenced June 3, 1898, and were still in progress at the close of the fiscal year, up to which time 436 linear feet of the row of new front piles and 220 linear feet of the row of rear piles had been driven. The front wale was on for a length of 320 feet and the rear wale for a length of 303 feet, and both secured with screw bolts and tie rods. The first course of superstructure was completed for a distance of 259 feet, the second course for a distance of 248 feet, and the third course for a distance of 227 feet.

The total expenditure for improvement and maintenance to June 30, 1898, was $127,340.08, of which $8,646.38 were spent during the past fiscal year. The available channel depth at the close of the year, as shown by survey made May 21–24, was 14 feet in the lower and 12 feet in the upper channel. The work done during the past year, with that in progress at its close, will make the repaired section of pier and revetment good for a long time; but a great deal of similar work remains to be done to make other sections of the old piers and revetments safe and serviceable.

The completion of the approved project calls for an extension of 200 feet to the south pier, and the maintenance of existing improvements requires repairs as indicated above, and dredging.

The estimate for the year 1900 is as follows: For pier extension, $18,000; rebuilding 1,000 feet of old pier, $10,000; dredging, $4,000; making in all, with due allowance for superintendence, engineering, and office contingencies, $35,000.

A special report in relation to this harbor was submitted December 19, 1896, and is printed in Report of the Chief of Engineers, United States Army, for 1897, pages 2953–2954, and also as House Ex. Doc. 144, Fifty-fourth Congress, second session. It was made under requirement of the river and harbor act of June 3, 1896, calling for the estimated cost of providing a navigable depth of 16 feet. The estimate was as follows:

Extending north pier 400 feet, at $100	$40,000.00
Extending south pier 500 feet, at $90	45,000.00
Dredging 40,000 cubic yards, at 15 cents	6,000.00
Repairs:	
Reconstruction of north plank-beam revetment, 945 feet, at $20	18,900.00
Repairs to north pier	6,000.00
Reconstruction of south plank-beam revetment, 1,528 feet, at $17.50	26,740.00
Repairs to south pier	2,820.00
	145,460.00
Contingencies, 10 per cent	14,540.00
Total	160,000.00

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The Light-House Establishment maintains a harbor light near the outer end of north pier.

Original estimated cost of the work, 1868, amended in 1876 and 1884.... $186,000.00
Whole amount expended to June 30, 1898..... 127,340.08

Money statement.

July 1, 1897, balance unexpended		$21,806.30
June 30, 1898, amount expended during fiscal year		8,646.38
July 1, 1898, balance unexpended		13,159.92
July 1, 1898, outstanding liabilities	$2,310.81	
July 1, 1898, amount covered by uncompleted contracts	5,610.78	
		7,921.59
July 1, 1898, balance available		5,238.33
Amount (estimated) required for completion of existing project		45,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		35,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations for improving harbor at Charlevoix, Mich.

August 14, 1876	$10,000	August 11, 1888	$12,500
June 18, 1878	12,000	September 19, 1890	9,000
March 3, 1879	9,000	July 13, 1892	10,000
June 14, 1880	10,000	August 18, 1894	8,000
March 3, 1881	10,000	June 3, 1896	20,000
August 2, 1882	10,000		
July 5, 1884	10,000	Total	140,500
August 5, 1886	10,000		

Abstract of bids for repairing Government pier at Charlevoix, Mich., received and opened March 30, 1898, in accordance with advertisement dated February 28, 1898.

No. of bid.	Name and address of bidder.	1.—To cut down and remove old work, etc. (723 linear feet), per linear foot.	2.—To furnish the following material and secure it in place. White oak round piles (7,250 linear feet), per linear foot.	White oak timber (7,920 feet B. M.), per M feet B. M.	White pine timber (121,724 feet B. M.), per M feet B. M.	White pine plank (6,480 feet B. M.), per M feet B. M.	Drift bolts (16,327 pounds), per pound.	Screw bolts (8,114 pounds), per pound.	Tie rods (6,461 pounds), per pound.	Spikes (293 pounds), per pound.	Angle irons (11,830 pounds), per pound.	Approximate total.
							Cts.	Cts.	Cts.	Cts.	Cts.	
a1	Robert B. Rice, Muskegon, Mich	$0.25	$0.26	$35.00	$19.00	$15.00	2	2½	2½	3	2½	$5,748.55
b2	Love & West, Muskegon, Mich	.65	.28	32.00	19.00	17.00	2	2	2	2	2	6,037.00
3	Joseph A. Beauvais, Charlevoix, Mich	.95	.25	28.50	19.75	19.75	2	2½	2½	2½	2½	6,201.43
4	Nelson J. Gaylord, Ludington, Mich	.30	.32	35.00	20.00	18.00	2	2	2	2	2	6,225.92
5	P. W. Galloway, Racine, Wis	1.00	.28	35.00	19.00	15.00	2½	3	3	2	3	6,646.53
6	Adolph Green, Green Bay, Wis	1.20	.28	35.00	19.50	16.95	2	2½	2½	2	3	6,710.12
7	Lynch & Weimer, Ludington, Mich	1.25	.31	40.00	22.00	18.25	2½	2 5/10	2 5/10	3	3	7,444.42
8	Lipsett & Grigg, Sault Ste. Marie, Mich	6.25	.52	50.00	19.75	19.00	3	3	3	3	3	12,502.86

a Contract entered into Apr. 9, 1898.
b Guarantors' signatures not witnessed; certificate not executed.

CONTRACTS IN FORCE FOR IMPROVING HARBOR AT CHARLEVOIX, MICHIGAN.

Green Bay Dredge and Pile Driving Company, dredging, dated March 26, 1897; approved April 13, 1897; date of beginning, April 1, 1897; date of expiration, September 15, 1897.

Jos. A. Beauvais, pier work, dated April 8, 1897; approved April 24, 1897; date of beginning, May 1, 1897; date of expiration, October 1, 1897; extended to November 1, 1897.

William A. Starke, dredging, dated April 9, 1898; approved April 20, 1898; date of beginning, April 15, 1898; date of expiration, September 15, 1898.

Robert B. Rice, pier work, dated April 9, 1898; approved April 20, 1898; date of beginning, May 1, 1898; date of expiration, October 1, 1898.

COMMERCIAL STATISTICS, CHARLEVOIX HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1888	526	92,306	1893	820	144,976
1889	473	.....	1894	1,701	338,015
1890	532	75,224	1895	528	92,387
1891	534	79,613	1896	420	75,263
1892	537	79,966	1897	545	110,474

Receipts and shipments by vessel, 1897.

[Compiled from statements furnished by W. H. McCartney, village clerk, Charlevoix, Mich., and by the collector of customs at Grand Haven, Mich.

Articles received.	Tons.	Articles shipped.	Tons.
Brick	1,500	Bark	10,500
Coal	4,809	Fish	677
Grain	1,317	Lumber	52,464
Lumber	339	Merchandise, general	287
Merchandise, general	1,955	Pig iron	1,300
Miscellaneous	45	Posts and ties	5,183
Pig iron	224	Potatoes	1,749
Salt	97	Slabs	17,572
Wood	225	Wood	20,493
Total	24,011	Total	110,226

K K 18.

IMPROVEMENT OF PETOSKEY HARBOR, MICHIGAN.

The project for the improvement of Petoskey Harbor, authorized in the river and harbor act of August 17, 1894, provides for the construction of an outer and detached breakwater, so designed as to shelter the landing pier from westerly storms and "possibly to furnish an additional area within which vessels could take shelter on occasions." Petoskey is situated on the southeast shore of Little Traverse Bay, and prior to improvements of its harbor the water front was wholly exposed to winds coming from between the west and northwest across Lake Michigan, so that it was hazardous to make a landing in the immediate vicinity during gales from the directions above indicated. Operations

were commenced in 1895, and up to June 30, 1897, 801 linear feet of breakwater had been constructed.

Operations during the past fiscal year were limited to repairing the damage to the inshore section of the west breakwater, this section being a slight mass of riprap in extension of the main crib structure. The repairs consisted in placing 70 cords of heavy riprap stone to supply voids caused by the action of heavy seas on the structure.

The total amount expended to June 30, 1898, was $51,731.31, of which $1,235.19 were spent during the past fiscal year.

To complete the improvement as projected requires 600 additional feet of breakwater, and the security of the cribs already placed requires considerable additions to the riprap foundations on which they rest. The estimate for 1900 is, therefore, as follows: 600 linear feet of breakwater construction, $72,000; additional riprap for crib foundations, $6,000; making in all, with due allowance for supervision, engineering, and office contingencies, $85,000.

The harbor is in the Grand Haven collection district, and the nearest port of entry is Grand Haven, Mich. The nearest light-house is at Harbor Point, 4 miles distant.

Original estimated cost of the work	$170,000.00
Whole amount expended to June 30, 1898	51,731.31

Money statement.

July 1, 1897, balance unexpended	$2,503.88
June 30, 1898, amount expended during fiscal year	1,235.19
July 1, 1898, balance unexpended	1,268.69
July 1, 1898, outstanding liabilities	24.00
July 1, 1898, balance available	1,244.69
Amount (estimated) required for completion of existing project	117,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	85,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving harbor at Petoskey, Mich.

September 19, 1890	$15,000
July 13, 1892	20,000
August 18, 1894	10,000
June 3, 1896	8,000
Total	53,000

COMMERCIAL STATISTICS, PETOSKEY HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1893	1,338	8,000	1896	3,156	24,000
1894	4,160	20,000	1897	4,362	91,000
1895	4,360	28,000			

Receipts and shipments by vessel, 1897.

[Compiled from statement furnished by Col. Isaac D. Toll, of Petoskey, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Fish	1,200	Farm products	75
Flour	100	Flour	600
Fruit	515	Lime and cement	1,000
Grain	440	Lumber	590
Hay and feed	100	Miscellaneous	325
Live stock	200	Potatoes	900
Merchandise, general	10,600	Tan bark	1,200
Miscellaneous	2,278		
Salt	210		
Total	15,643	Total	4,690

K K 19.

SURVEY OF KALAMAZOO RIVER, MICHIGAN, FROM SAUGATUCK TO NEW RICHMOND.

[Printed in House Doc. No. 233, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, January 13, 1898.

SIR: I have the honor to submit the accompanying copy of report of December 28, 1897, with map,* by Capt. C. McD. Townsend, Corps of Engineers, of the results of a survey of Kalamazoo River, Michigan, from Saugatuck to New Richmond, made to comply with requirements of the river and harbor act of June 3, 1896.

Four projects for improvement are presented, as follows:

1. For a channel with a depth of 4 feet at low water and bottom width of 50 feet $85,000
2. For a channel with a depth of 6 feet at low water and bottom width of 75 feet 50,000
3. For a channel with a depth of 8 feet at low water and bottom width of 100 feet 100,000
4. For an 8-foot channel extending through Indian Channel and abandoning the main river from head of Indian Cut to Indian Point 78,000

Captain Townsend estimates that the channel dredged could be maintained at an annual cost not exceeding 10 per cent of the original outlay.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. C. M'D. TOWNSEND, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Grand Rapids, Mich., December 28, 1897.

GENERAL: In compliance with section 9 of the river and harbor act of June 3, 1896, I have the honor to submit the following report of

*Not reprinted. Printed in House Doc. No. 233, Fifty-fifth Congress, second session.

the survey of Kalamazoo River, Michigan, from Saugatuck to New Richmond:

The field work of the survey was executed from October 20, 1896, to January 15, 1897, and the results platted at such times as the force was not required on other work. A tracing of the map* is submitted herewith, and there is appended a report of Assistant Engineer G. W. Bunker, in local charge of the survey party, which explains the methods pursued and the results attained.

From Saugatuck to New Richmond the distance by river is 8.67 miles. From Saugatuck across Kalamazoo Lake a navigable channel now exists of a depth of 12 feet, and at the stage of water at which the survey was made a navigable channel of 4 feet depth was found to New Richmond, with the exception of a portion of the river between Indian Channel and Indian Cut, where the river is divided into two channels, the one following the main stream, the other flowing through Indian Cut, Indian Bayou, and Indian Channel. The object of the survey has not been stated in the act; estimates are therefore submitted for four projects:

First. A channel with a depth of 4 feet at low water and bottom width of 50 feet.

Dredging 8,053 cubic yards, at 25 cents	$2,013.25
Closing Indian Cut	1,000.00
Contingencies	1,986.75
Total	5,000.00

Second. A channel with a depth of 6 feet at low water and bottom width of 75 feet.

Dredging 213,537 cubic yards, at 15 cents	$32,030.55
Closing Indian Cut	1,000.00
Contingencies	16,969.45
Total	50,000.00

Third. A channel with a depth of 8 feet at low water and bottom width of 100 feet.

Dredging 757,253 cubic yards, at 12 cents	$90,870.36
Contingencies	9,129.64
Total	100,000.00

Fourth. An 8-foot channel extending through Indian Channel, and abandoning the main river from Indian Bayou to Indian Cut.

Dredging 583,913 cubic yards, at 12 cents	$70,069.56
Contingencies	7,930.44
Total	78,000.00

A trouble usually encountered in surveys of streams where no records of river gauges have been preserved was here experienced. There is no way to determine either the low-water discharge or low-water slope. The lowest stages that have occurred at Saugatuck and New Richmond *since the 20th of October, 1896*, have been observed and a slope and discharge derived therefrom. Estimates of cost of projects can therefore only be approximate, and I have introduced large items for contingencies for this reason in the estimates for both the channel of 4 and 6 foot depths. The construction of an 8-foot channel would so disturb the

*Only reduced sketch map printed.

regimen of the river that the low-water surface at New Richmond would be but slightly higher than that of Lake Michigan, and the probable errors in the computed slope or discharge would not so materially affect the results. The advantages of the channel through Indian Bayou consist not only in the reduction in first cost, but in a shortening of the length of the river a little over 1 mile, and the avoidance of the sharp bends which occur in the portion of the main stream excluded. As the river carries little sand even in flood, and its banks are stable, it is estimated that the channel dredged could be maintained at an annual cost not exceeding 10 per cent of the original outlay.

* * * * * * *

Very respectfully, your obedient servant,

C. McD. TOWNSEND,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. G. W. BUNKER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Grand Rapids, Mich., December 27, 1897.

SIR: I have the honor to submit the following report of the survey of Kalamazoo River, Michigan, from Saugatuck to New Richmond, assigned to me October 20, 1896, together with the consideration of improving the river so as to obtain either a 4, 6, or an 8 foot navigable channel from Saugatuck to New Richmond.

FIELD OPERATIONS.

The field operations embrace the following heads, viz:

1. A topographical survey of the river valley, including soundings.
2. Borings in the bed of the river.
3. Discharge observations.

(1) *Survey.*—A preliminary examination of the portion of the river to be surveyed showed that it had a length of 8.67 miles, and that for a distance of about 3½ miles immediately below New Richmond the river followed a tortuous path through a low, heavily wooded bottom land, which was flanked on one side by bluffs about 50 feet in height and on the other by a wet marsh of considerable extent. The banks of the river through this stretch had an elevation of about 3 feet above the low-water stage and showed very few signs of erosion. From the 3½-mile point to Kalamazoo Lake at Saugatuck the course of the river is through a wet marsh, which at low stages of the water shows small patches of solid ground, but at high water is a marshy lake extending from bluff to bluff, a distance varying from one-eighth to 1½ miles.

The banks of this lower portion of the river, though solid, vary in height above the low-water stage from a few inches to about 2½ feet.

The work of the survey began October 26, 1896, and ended January 15, 1897. The party consisted of a transit man, 2 recorders, 2 stadia men, a leadsman, 3 boatmen, and 2 axmen.

Soundings in the river and adjacent bayous and lakes were made on cross lines or ranges 100 feet apart, and stakes bearing the number of the sounding station were driven to mark the ends of the lines. On these cross lines the soundings were taken 20 feet apart. In taking soundings in Kalamazoo Lake and Indian Bayou the "range and intersection" method was used. Soundings were taken on ranges with a time interval between soundings of fifteen seconds. The interval between transit intersections was one minute.

In order to provide an opportunity for checking the stadia lines, five triangulation stations were established in convenient places and afterwards located from a base line, which was formed by extending the line made by two of the triangulation stations of the 1895 survey at Saugatuck Harbor. The maximum error of closure in any of these triangles was 25".

The development of topography was with the stadia, starting from a line between

two of the triangulation stations of the 1895 survey of Saugatuck and reading azimuths around to the right from the true north.

In order to develop the river valley from bluff to bluff, three transit lines were found necessary. The main line followed the course of the river from Saugatuck to New Richmond, while the side lines followed the contour of the bluffs. These lines were checked on the triangulation stations and at various intervals upon each other. The maximum error of closure in any line was 30″.

The datum of both stadia and level lines was that of Lake Michigan, viz, 3.06 feet below high water of 1883.

To preserve on the ground traces of the survey for future reference, the instrument stations along the main line were marked with a gas-pipe device of the following description, viz: On one end of a piece of 1-inch gas pipe, which was 3 feet long, was screwed a 6-inch cast-iron flange; the other end was covered with an ordinary malleable iron cap, and the whole was painted with asphaltum to prevent its rusting. A post-hole digger was used to make the holes in which these gas-pipe "markers" were set. The earth was thoroughly tamped around them, leaving the top of the cap about 2 inches above the ground. On the top of the cap a square was picked with a prick punch to indicate the stadia station, and around the edge its number was marked in like manner. Bearing trees and other references were marked and located to assist in finding these stations in the future. The main-line stations from Saugatuck to the Pottawattamie Club House have these markers. From the latter place to New Richmond cedar posts, 4 feet long, set about 3½ feet in the ground, and bearing a center mark (a nail) in their tops, were used to mark the instrument stations.

A line of levels was run from the United States water gauge at Saugatuck Harbor to the upper end of the survey at New Richmond and return. The error in closure was 0.13 foot, which, considering the nature of the ground over which the line was run and the total length of the line, viz, 19.8 miles, was deemed sufficiently close for the purpose of the survey. In so far as was possible, the gas-pipe stations of the main stadia line were used as benches and their number marked upon the pipe of the station with a prick punch.

A series of gauges were established at intervals of about one mile, beginning at Saugatuck and extending to the upper end of the survey. The zero of each gauge was set at the elevation of the Lake Michigan datum.

(2) *Borings.*—From the highway bridge between Saugatuck and Douglas to the upper end of the survey 33 borings were made in the bed of the stream and in bayous. They vary in depth below the surface of the water from 12 to 15 feet.

The float from which they were made was composed of two ordinary 4 by 16 foot scow boats, fastened together by a platform 12 feet square. The platform furnished a working area for the men and a support for a windlass with which the pipe was drawn after it was driven.

Through an 8-inch hole in the platform a 3-inch casing pipe was lowered until it rested on the river bed. Through this casing a 2-inch driving pipe, shod with a steel annular shoe, was driven to the required depth. The material through which the shoe passed was forced up into the pipe and there observed through small holes in the pipe, which were drilled for that purpose.

Each boring was located by measurements to the nearest sounding stations, and the elevation of the water surface was determined from gauge readings taken above and below the boring.

From the following table the results of borings can be seen:

Record of borings.

No. of boring.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Station.	Remarks.
		Feet.	*Feet.*	*Feet.*	1896.		
1	1. Water	8	8	−1.4	Nov. 24	0+25	
	2. River sand	12.3	4.3				
2	1. Water	7	7	−1.2	Nov. 24	24+55	
	2. River sand	12	5				
3	1. Water	7.5	7.5	−0.95	Nov. 25	49+65	
	2. River sand	12.5	5				
4	1. Water	5.5	5.5	−0.65	Nov. 25	74+85	
	2. River sand	12	6.5				
5	1. Water	9	9	−0.45	Nov. 25	99+85	
	2. River sand	12	3				
6	1. Water	7	7	−0.2	Nov. 26	114+55	
	2. Sand	12	5				

Record of borings—Continued.

No. of boring.	Material.	Depth.	Thickness.	Elevation of water surface.	Date.	Station.	Remarks.
		Feet.	*Feet.*	*Feet.*	1896.		
7	1. Water	8	8	−0.15	Nov. 26	119+73	
	2. Sand	12	4				
8	1. Water	6	6	−0.1	Nov. 27	121+55	
	2. Sand	12	6				
9	1. Water	6.5	6.5	−0.1	Nov. 27	122+75	
	2. Sand	11.5	5				
	3. Clay	12	.5				
10	1. Water	9	9	−0.1	Nov. 25	124+85	
	2. Sand	10	1				
	3. Clay	12	2				
11	1. Water	6	6	−0.05	Nov. 27	126+40	
	2. Sand	12	6				
12	1. Water	6	6	−0.05	Nov. 27	127+80	
	2. River sand	12	6				
13	1. Water	6	6	0.0	Nov. 27	129+50	
	2. Mud and sand	12	6				
14	1. Water	7	7	+0.05	Nov. 27	134+60	
	2. Sand	12	5				
15	1. Water	7.5	7.5	+0.2	Nov. 27	144+68	
	2. Sand	12	4.5				
16	1. Water	5.5	5.5	+0.25	Nov. 27	149+73	
	2. River sand	12	6.5				
17	1. Water	7	7	+0.5	Nov. 28	175+60	
	2. River sand	12	5				
18	1. Water	7.5	7.5	+0.9	Nov. 28	199+60	
	2. River sand	12	4.5				
19	1. Water	8	8	+1.2	Nov. 28	224+58	
	2. River sand	12	4				
20	1. Water	7.5	7.5	+1.7	Nov. 30	250+35	
	2. River sand	12	4.5				
21	1. Water	8	8	+2.0	Nov. 30	273+70	
	2. River sand	12	4				
22	1. Water	8	8	+2.3	Dec. 1	300+30	
	2. River sand	12.5	4.5				
23	1. Water	9	9	+2.5	Dec. 1	324+70	
	2. Sand	10.5	1.5				
	3. Gravel and sand	12	1.5				
24	1. Water	8.5	8.5	+2.75	Dec. 1	351+50	
	2. River sand	12.5	4				
25	1. Water	7	7	+2.95	Dec. 2	374+65	
	2. River sand	12	5				
26	1. Water	9	9	+3.2	Dec. 2	399+53	
	2. River sand	13	4				
27	1. Water	10	10	+3.5	Dec. 2	424+55	
	2. River sand	14	4				
28	1. Water	8	8	+3.7	Dec. 3	449+80	
	2. River sand	12.5	4.5				
29	1. Mud and sand	15	15	+3.37	Dec. 3	Opposite New Richmond depot.	In neck of land at river bend on line between stations 425–392, and 315 feet from station 392.
30	1. Mud and sand	4	4	+2.73	Dec. 3	....do.....	In neck of land at river bend on line between stations 367–333, and 470 feet from station 367.
	2. Coarse sand and gravel.	12	8				
	3. Clay	13	1				

INDIAN CUT.

31	1. Water	9	9	−0.2	Dec. 8	25+30	
	2. Mud and blue clay.	14	5				
32	1. Water.	2	2	0.0	Dec. 8	49+55	
	2. Mud and fine sand.	13	11				
33	1. Water.	7	7	+1.55	Dec. 4	76+40	
	2. River sand.	12	5				

(3) *Discharge observations.*—When the directions for this work arrived, winter had set in and the river was full of floating ice, which from time to time gorged on the bars, or in the sharp bends, and backed the water up so that it formed ponds, in which the conditions of area of cross section and velocity were not true for the natural discharge of the stream.

On December 24 a portion of the river was clear of floating ice for about three hours. During that time a place was chosen and the discharge observations were made. Later in the day, after the observations were completed, it was found that a gorge had formed below the discharge section, and that the water was rapidly rising. This threw doubt upon the correctness of the observed velocity and slope. No further opportunity for gauging was offered before January 15, 1897, when the survey was completed.

The observed discharge December 24 was 814 cubic feet per second. The elevation of the water surface at the discharge section was +3.1, and at New Richmond +3.3, giving a fall of 0.2 foot in 2 miles, or 0.1 foot per mile, while the fall in the water surface between New Richmond and Saugatuck, a distance of 8.31 miles, was 5.4 feet, or 0.65 foot per mile, which shows that the water surface at the discharge section was 1.1 feet above the direct slope from New Richmond to Saugatuck on that day. It is evident from these figures that the ice gorge below the discharge section had produced an abnormal elevation of the water surface at the section, and that the velocity was in consequence diminished, giving a discharge much too small. This is further proven by taking from the gauge readings at Saugatuck and New Richmond (when the river is clear of ice) a slope which would be consistent with a +3.1 slope at the discharge section and by means of the Kutter formula determining the velocity, and from that the discharge which the river should have at that stage, viz, 2,744 cubic feet per second.

In consideration of these facts the observed discharge (814 cubic feet per second) is deemed entirely unreliable, and it is therefore discarded.

The computations for low-water discharge and the probable water surfaces over the contemplated improvements by dredging were made by use of the Kutter formula.

During the time of the survey there was no opportunity to observe extreme low water. The lowest recorded gauge reading at Saugatuck was —2.3, taken in December, 1896; that at New Richmond was +1.8, taken in August, 1897. A straight line was drawn between these points, making a slope of 0.0000934, or 0.493 foot per mile, and this was considered a fair approximation of the mean low-water slope, and it was used in computing the probable low-water surface in the dredged channels.

Three projects for improvement of the main river by open dredge cuts were contemplated, viz:

1. A cut giving 4 feet of water with a 50-foot base.
2. A cut giving 6 feet of water with a 75-foot base.
3. A cut giving 8 feet of water with a 100-foot base. All side slopes to be 2 feet to 1 foot.

(1) It was thought that the 4-foot cut, when made, would not appreciably change the low-water slope.

(2) In considering the probable water surface after a 6-foot cut has been made, a mean cross section of the river was constructed, having a top width equal to the mean width of the river between the discharge sections, side slopes of 2 feet to 1 foot, and a proper center depth to give the mean low-water area to the section. Through the bottom of this model section it is proposed to make a dredge cut which shall have a bottom width of 75 feet, side slopes of 2 feet to 1 foot, and such a depth as is necessary to give a total depth of 6 feet to the water in the improved section, keeping the conditons of area and velocity proper for the low-water discharge.

The change in the form of the model cross section as a result of dredging would necessitate a drop in the water surface at the discharge section and a consequent change in the rate of slope over the dredged cut.

In determining this drop in the water surface the following formula was used:

$$d''=\frac{(l-a)^2-4\,(D-d)^2 \perp \sqrt{(a-l)^2-8\,(D-d)\left\{2\,(D-d)+(a+l)\right.}}{8}$$

and $d'=D+d''-d$, in which—

D = depth of water after dredging = 6′.
d = center depth of water before dredging = 4.7945.
d' = distance from bottom of model section to the bottom of dredged section.
d'' = "drop" in water surface caused by dredging.
l = top width of model section before dredging = 160.75.
a = bottom width of dredge cut = 75′ as in fig. 1.

Solving, after substituting the numerical values, we get $d''=1.228'$ = the drop in the water surface occasioned by dredging.

Having determined the mean hydraulic radius of the improved section from the wet perimeter and the area, and fixed upon 0.025 as a coefficient of roughness in Kutter's formula for C, and retained the velocity of the low-water discharge, we substitute these values in the formula

$$S=\frac{V^2}{C^2r}$$

(in which S=slope, V=velocity, and r=mean hydraulic radius), and solving get 0.0000883 as a value for the slope of the water surface over the dredged channel.

(3) In considering an 8-foot channel with a bottom width of 100 feet and side slopes of 2 feet to 1 foot its area was found to exceed that of the mean low-water section, and this necessitated a less velocity and a flatter slope in order to maintain the low-water discharge through the channel. By dividing the low-water discharge by the area of the section of the 8-foot channel a proper velocity was found. From the wet perimeter and the area the mean hydraulic radius was determined, and in assuming a value for C in Kutter's formula 0.025 was chosen as a coefficient of roughness. Solving with these values a slope of 0.000026 was found for the 8-foot improvement.

"INDIAN CHANNEL CUT-OFF."

As an alternative for the 8-foot channel by the main river the following proposition is submitted, viz:

To make an 8-foot dredged channel with bottom width of 100 feet and side slopes of 2 to 1, starting at New Richmond and following the main river to the head of Indian Cut, thence through Indian Cut, Bayou, and Channel, striking the river again at Indian Point and following it to Kalamazoo Lake at Saugatuck. This route will shorten the total length of the improvement 5,700 feet, and avoid several sharp bends and the shoalest part of the river. It will be seen from a comparison of the estimated costs that it is also the cheapest route.

From a gauging of Indian Cut it was found that at low water about one-half of the discharge of the river passed through this route.

In view of the fact that the element of supposition forms so great a part of all formulæ for computing velocity or slope in a natural stream, the following values are considered the probable conditions of this river:

Stage of water at New Richmond.	Stage of water at Saugatuck.	Slope.	Velocity.	Discharge per second.
				Cubic feet.
+4.7	—2.1	.0001549	2.456	2,700
+3.3	—2.1	.000123	1.999	1,800
+1.8	—2.3	.000098	1.580	a 1,000

a Low-water stage.

The following tabular statement shows the conditions that are supposed to maintain in the dredged channel at low water:

Depth of water in dredged channel.	Width of dredged channel on bottom.	Stage of water at New Richmond.	Stage of water at Saugatuck.	Slope.	Velocity.	Discharge per second.
Via main river:	*Feet.*					*Cubic feet*
4 feet	50	+1.8	—2.3	.000093	1.580	a 1,000
6 feet	75	+0.3	—2.3	.000088	1.580	1,000
8 feet	100	—1.2	—2.3	.000026	1.28	1,000
Via Indian Cut:						
8 feet	100	—1.1	—2.3	.000026	1.23	1,000

a Same as low water.

Summary of field operations.

1.	Triangulation stations set	5
2.	Triangulation stations occupied	9
3.	Square miles of area covered by triangulation	12
4.	Stadia stations set and occupied	138
5.	Stadia points located	6,518
6.	Topography taken by stadia, in square miles	7
7.	Length of stadia line, in miles	27.6
8.	Length of level line, in miles	19.8
9.	Bench marks established	23
10.	Gauges established	13
11.	Discharge observations	2
12.	Soundings taken	8,709
13.	Stakes made and set	1,939

MAPS.

Owing to the pressure of other business, the reduction and platting of the field notes was delayed until July 16, 1897. On September 30 this work was further delayed by the resignation of the draftsman who had it in charge, and it was not taken up again until November 1. From this time until the maps and profile were completed, December 27, 1897, no delays occurred.

The topography has been platted on three sheets for the sake of convenience in handling.

Due to the reduced scale of the map, viz, 400 feet to 1 inch, only about one-fourth of the soundings taken have been platted. They were all used, however (after being reduced to the low-water datum), in estimating the quantities to be dredged. Contour lines have been drawn to show the 2, 5, and 10 foot elevations above the Lake Michigan datum.

A reduced map of the river from Saugatuck to New Richmond, on a scale of 1 inch to 36,000 feet, has been inserted in Sheet 1.

PROFILE.*

A profile of the river from Saugatuck to New Richmond has been prepared, showing the low-water surface, the probable water surface for each one-half-foot rise on the New Richmond gauge from +2 to the +5 foot stage, the location and depth of borings, and a mean profile of the river bed averaged for a width of 75 feet.

The line along which this profile is made is shown on the maps as the "proposed channel." The lines showing the bottom of the proposed dredging are also shown on this profile.

Gauge readings.

Gauge location.	1. Harbor gauge.	2. Saugatuck.	3. St. Pier Point.	4. Peach Orchard.	5. Purdys.	6.	7.
Low-water reading	—2.6	—2.3	—1.95	—1.49	—0.94	—0.5	Never set.
Highest observed reading	—1.5	—0.75	—0.2	+0.4	+2.0	+2.7	
Lowest observed reading	—2.6	—2.25	—1.8	—1.1	+0.2	+0.7	
Sounding station			36	37	143+75	192	

Gauge location.	8. Red Banks.	9. Catfish Bend.	10.	11. New Richmond.	12.	13. Indian Bayou.
Low-water reading	+0.45	+1.0	+1.45	+1.8	+1.95	—0.11
Highest observed reading	+4.4	+4.6	+5.4	+7.3	+4.3	—0.3
Lowest observed reading	+1.65	+2.25	+2.9	+2.45	+3.7	—0.15
Sounding station	292+05	353+90	400+86	439	456+65	

*Not printed.

Mean monthly readings.

Month.	Harbor gauge.	Saugatuck.	New Richmond.
October	—2	—1.88	+2.7
November	—2.18	—1.14	+4
December	—2.20	—1.30	+3.4
January	—1.91	—0.15	+5.5

Estimated cost of dredging.

	Amount to be dredged.	Estimated price.	Total cost.
Via main river:	*Cu. yds.*	*Per cu. yd.*	
For the 4-foot improvement	8,053	$0.25	$2,013.25
For the 6-foot improvement	213,537	.15	32,030.55
For the 8 foot improvement	757,253	.12	90,870.36
Via Indian Cut:			
For the 8-foot improvement	583,913	.12	70,069.56

Respectfully submitted.

G. W. BUNKER, *Assistant Engineer.*

Capt. C. McD. TOWNSEND,
Corps of Engineers, U. S. A.

APPENDIX L L.

ENT OF RIVERS AND HARBORS ON THE EASTERN COAST OF GAN AND OF WATERS CONNECTING THE GREAT LAKES.

F LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS, OFFI- CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

ıal connecting the waters of eat Lakes between Chicago, ı, and Buffalo.
s River at the Falls, Michigan.
ıg and care of St. Marys Falls Michigan.
ıe Channel, St. Marys River, gan.
gan Harbor, Michigan.
Harbor (Thunder Bay River), gan.
' River, Michigan.
ng River, Michigan.
of refuge at Sand Beach, Lake , Michigan.
10. Mouth of Black River, Michigan.
11. Black River at Port Huron, Michigan.
12. Pine River, Michigan.
13. Belle River, Michigan.
14. St. Clair Flats Canal, Michigan.
15. Operating and care of St. Clair Flats Canal, Michigan.
16. Clinton River, Michigan.
17. Detroit River, Michigan.
18. Rouge River, Michigan.
19. Turning Basin in Rouge River, Michigan.

SURVEYS.

r, Shiawassee, Bad, and Flint , Michigan.
21. Saginaw River, Michigan.
22. Rouge River, Michigan.

HARBOR LINES.

23. St. Clair River at Port Huron, Mich.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 29, 1898.

AL: I have the honor to submit herewith the annual report o the works of river and harbor improvement in my charge cal year ending June 30, 1898.
ry respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

en. JOHN M. WILSON,
Chief of Engineers, U. S. A.

L L 1.

IMPROVEMENT OF SHIP CHANNEL CONNECTING WATERS OF THE GREAT LAKES BETWEEN CHICAGO, DULUTH, AND BUFFALO.

This improvement was entered upon in accordance with the following provision of the river and harbor act of July 13, 1892:

For ship channel twenty and twenty-one feet in depth and a minimum width of three hundred feet in the shallows of the connecting waters of the Great Lakes between Chicago, Duluth and Buffalo, three hundred and seventy-five thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to carry out the plans proposed by General O. M. Poe, Corps of Engineers, United States Army, dated January twentieth, eighteen hundred and ninety-one, and printed as House Executive Document, Numbered Two hundred and seven, second session, Fifty-first Congress, for such ship channel, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two million nine hundred and sixty-five thousand dollars, exclusive of the amount herein appropriated.

The estimated total cost was $3,340,000.

Contracts for work at all points specified in the project were entered into December 31, 1892. Operations under them were commenced in the spring of 1893, and by June 30, 1897, work under all except that relating to the bar at the mouth of Detroit River had been completed. The removal of a dangerous shoal in Mud Lake, near Point aux Frênes, covering an area of 400 by 1,400 feet, which was not known of when the project was adopted, had also been nearly completed. The history of these operations is printed in Annual Report of the Chief of Engineers for 1896 (pp. 2749 to 2756) and for 1897 (pp. 2956 to 2958).

Operations during the last fiscal year comprised (1) work for increasing the width and depth of channels as originally completed, through Round Island Shoals, St. Marys River, this being essential to make navigation through these channels reasonably safe on account of their exposure to heavy seas rolling in from Lake Superior, and the prevalence of fogs in the spring and fall months; (2) completing the removal of Point aux Frênes Shoal, foot of Mud Lake, St. Marys River, thereby clearing the direct line of travel of a dangerous obstruction, of which there was no knowledge when the original project was submitted; (3) removing part of the Middle Ground Shoal at Port Huron, St. Clair River, thereby widening and straightening the main ship channel and making navigation very much safer; (4) removing bowlders, rock, and other material from the ship channel in lower section of the Detroit River, which now constitutes the only link in the line of through travel at which the required depth of 20 feet has not yet been obtained; the result of the year's work was to increase the available depth from 16½ feet to 18 feet at the present stage of water; (5) completing channel through bar at mouth of Detroit River (section 8 of the ship channel). This work was in progress from the spring of 1893 until October 29, 1897, under contract with L. P. & J. A. Smith, of Cleveland, Ohio, dated December 31, 1892, calling for dredging a channel 21 feet deep and 800 feet wide for a distance of about 26,500 feet. The total amount of material removed during the progress of the work was 1,093,916 cubic yards, scow measure, of which 82,793 cubic yards were taken out during the last fiscal year. Work done under items 2, 3, and 5 was completed and that under 1 and 4 is still in progress.

The work of dredging Middle Ground Shoal, St. Clair River (item 3, above), was done between December 1, 1897, and May 31, 1898, under a contract with Edmund Hall, of Detroit, Michigan, dated May 13, 1897; the amount excavated was 55,579 cubic yards, the effect being to

eliminate a sharp bend in the ship channel and increase the width at that point from 750 feet to 1,500 feet.

The details of work done in the St. Marys River (items 1 and 2 above) are given in the following report prepared by Assistant Engineer Benno Rohnert, who had special charge of it:

Item D.—Shoal 29, section 4.—In lower end of Mud Lake, off Point aux Frênes, 400 feet by 1,400 feet. Contract dated September 19, 1895; W. A. McGillis & Co., of Chicago, Ill., contractors. Rates, earth 65 cents, and rock $3.75 per cubic yard, bank measure, to 21-foot grade, and half rates between 21 and 23 feet. Material, bowlders, clay, and limestone rock in situ. Contractors began work on this section September 3, 1896.

Work was continued till October 15, 1897, with one dredge and one diving outfit. The dredge worked 218 hours, was delayed 836 hours, and excavated 3,525 cubic yards, scow measure. The diver worked 482 hours, was delayed 286 hours, and raised 493 yards. The final examination was made with the raft bars during October, at the same time removing all points projecting above grade. The duplicate computations for final estimate were finished and submitted October 25.

The computed bank measure of material excavated from above the 21-foot grade is 8,081.35 cubic yards, of which 117.77 are rock; between 21 and 23 foot grades, 17,877.96, of which 260.53 are rock; below the 23-foot grade, 5,015.23, making a total of 30,974.54 cubic yards.

Item A.—Improving channel through Round Island Shoal No. 1 for 2,000 feet length, 800 feet width, and 23 feet depth. Contract dated September 13, 1897; Arthur H. Vogel, Milwaukee, Wis., contractor. Rates, 34 cents per cubic yard, bank measure, to 23-foot grade and half rates between 23 and 24 feet. Material, sand, clay, and bowlders.

One dredge has been operated since September 25, save from November 20 to April 26, when it was laid up for the winter season. Time worked, 742½ hours; delayed by heavy winds and breakages, 458½ hours. There were excavated 94,641 cubic yards, scow measure, of material. The south half of the channel has been dredged and will be examined with the raft bars during July to ascertain whether or not it can be thrown open to navigation.

Item B.—Improving channel through Round Island Shoal No. 2 to a depth of 23 feet, 800 feet wide by 2,900 feet long. Contract dated September 13, 1897; M. Sullivan, Detroit, Mich., contractor. Rates, 52 cents per cubic yard, bank measure, to 23 feet grade and half rates between 23 and 24 feet. Material, sand, clay, and bowlders.

Work was begun with one dredge on September 21, stopped for the winter November 17, and resumed April 26. Two additional dredges were placed on the section, the one in May and the other in June. They worked 1,371 hours, were delayed 442 hours, and excavated 55,281 cubic yards, scow measure.

Surveys and examinations with raft bars.—Round Island Shoals 1 and 2 were sounded during February in order to show their conditions at the close of the season of 1897; the area between the shoals and for a short distance above Shoal 1 for additional shoals. Two small ones were found to the northward of Shoal 1, and may be removed under the contract now in force. The hydrographic party set 120 stakes to mark the lines of soundings, which numbered 19,725. The examination with raft bars of the river above the shoals was begun. A survey for final estimate of Item D, Shoal 29, section 4, was made in October when one gauge stake was set, 10 section stakes driven, and 400 soundings taken. All soundings taken during the year were reduced and mapped on tracing linen or platted on cross-section sheets as occasion required.

General remarks.—For the guidance of contractors 75 section stakes were driven, and 26 gage boards placed. The azimuths from two triangulation stations to the 75 stakes were computed. The channel buoys in the vicinity of Shoals 1 and 2 were located by transit pointings and the rectangular coordinates referred to △ 19, survey of 1879, were computed.

A report and sketch showing proper locations of all range targets, lights, and buoys marking section 3 (Sailors Encampment), were prepared and submitted.

The quarters boat *Hay Lake* and tugs *Antelope* and *Myra* were laid up in the fall and fitted out in the spring.

The following extract from report by Assistant Engineer Charles V. Dixon gives details of operations on the lower Detroit River and bar at its mouth (items 4 and 5 above), of which he had immediate charge:

Grosse Isle Lower Range.—The work was commenced under a verbal agreement with Mr. Michael Sullivan, of Detroit, Mich., October 2, and continued until December 22, 1897, when the formation and run of ice in the river caused a suspension of operations for the season. They were resumed May 3, 1898, under a formal contract

with the same party, dated April 28, 1898, and were still in progress at the close of the fiscal year. The work has consisted in drilling and blasting bed rock and large bowlders, and in removing the blasted material together with all other material found above the prescribed grade; the work of removal being done by divers and loaded on derrick scows, or by dredging, as circumstances required. The object in view is to clear the channel of all obstructions to the depth of 21 feet and width of 600 feet.

The amount of material removed during the fiscal year is as follows:

By verbal agreement (October 2 to December 22, 1897) 9,326.224 tons.

Under formal contract dated April 28, 1898, 3,620.254 tons.

Under formal contract dated April 28, 1898, 4,528 cubic yards.

The material was removed from the east side of the range line indicated, and the area worked over was about 150 feet wide by 6,200 feet long. This area is indicated by shading on the sketch, area "b" being improved by dredging, and areas "a" and "d" by the removal of bowlders by derrick scow and diver.

The least depth throughout this area prior to improvement was about 14 feet; there is now a clear depth of 20 feet, with but few points to be removed in order to secure 21 feet.

Amherstburg Reach.—The improvement along this course was commenced on May 23, under contract dated May 2, 1898, with James Rooney, of Toledo, Ohio, for furnishing and operating a dredging plant. The present project contemplates a straight channel throughout this part of the river 400 feet wide and 21 feet deep. The area thus far improved by dredging is 200 feet wide (east half of channel) and 1,400 feet long, as shown on sketch (area "g"). The amount of material removed to date is 5,523 cubic yards, and the dredge has worked $399\frac{37}{60}$ hours. The removal of this material has cost the United States 65 cents per cubic yard. The material removed consists of sand and clay, with many bowlders embedded, and some limestone bed rock. It is expected that this bed rock will be required to be drilled and blasted in order to secure a clear depth of 21 feet throughout the course.

The least depth prior to this improvement was about 17 feet, and as yet the work has not progressed so as to affect this. There has been erected a temporary range on the Canadian shore to guide vessels in passing the area being improved. Along this range and for 100 feet either side of it there is a clear depth of 18 feet, this being the maximum depth over the shoalest places in the channel for the present stage of water. The location of this range is indicated on the sketch.

Hackett Range.—Improvement along this course was continued under contract dated December 31, 1892, with Messrs. L. P. & J. A. Smith, of Cleveland, Ohio, until October 29, 1897, when the work under this contract was completed. The amount of material removed under this contract during the fiscal year was 82,793 cubic yards. This material was sand, clay, gravel, bowlders, and loose stones, and was removed from areas "i," "j," "k," "l," and "m," indicated by shading on the sketch. Areas "i," "j," and "k" were improved by dredging, and areas "l" and "m" by the removal of bowlders by derrick scow and diver. The least depth of water prior to this improvement was about 17 feet, and there is now a clear depth of 21 feet for a width of 600 feet, with the exception of the shoal included within the outlines of area "j." This shoal, which extends from 150 feet to 300 feet west of the center line of channel and is about 1,000 feet long, is bed rock, over which the general depth varies from 20 feet to 21.5 feet, but there are points of bed rock which limit the clear depth to about 19 feet.

Removing obstructions from the channel by hired labor.—During the months of March and April, 1898, two derrick scows with diving outfits were operated by hired labor, for the purpose of removing bowlders from the channel of Lime Kiln Crossing (area "e" on sketch). There were removed from this area 583 tons of bowlders and loose stones, which were distributed over the entire area. Prior to this improvement the least depth of water was 18 feet. There is now a least depth of 19.2 feet for a width of 440 feet throughout this part of the channel, this least depth being limited by points of bed rock.

During the months of May and June, 1898, one derrick scow with diving outfit has been engaged in removing bowlders from the channel at Amherstburg Reach. Areas "f" and "h" have been partially cleared to 21 feet depth by the removal of bowlders, the remaining bowlders being too large to remove by the appliances at present in use. The least depth of water within these areas prior to this improvement was 18 feet. There is now a least depth of about 20 feet.

This derrick scow is now engaged in removing obstructions thrown up by the dredge and in clearing to 21 feet the area improved by dredging. There have been removed 726.22 tons of bowlders.

Surveys.—During the months of October and November, 1897, soundings were taken from a raft at the corners of 10-foot squares throughout the Lime Kiln Crossing course. This was done in order to estimate the amount of material to be

removed in widening the channel an additional 160 feet to the westward, thus securing a channel 600 feet in width. The amount of this material to be removed was found to be, above 21 feet, 60,880 cubic yards; between 21 feet and 23 feet, 33,085 cubic yards. During the month of February, 1898, an ice survey was made along the Hackett Range, covering the entire area improved during the season of 1897 under the contract with Messrs. L. P. & J. A. Smith. These soundings were taken 10 feet apart on cross sections and 20 feet apart on longitudinal sections. This work was done in order to determine the general depth of water resulting from the improvement.

Surveys and examinations were made during the year, in connection with works of improvement in progress or with a view to projecting further work, as follows: (1) Survey for final estimate on work done at Point Aux Frênes Shoal was made in October, 1897. (2) Ice surveys were made during February, 1898, of Round Island Shoals 1 and 2, St. Marys River, the area included between the shoals and a short distance beyond the outermost one (No. 1), in order to compute the amount of work done during the working season of 1897 and to develop two small shoals found in that locality, the number of soundings taken in these surveys being 19,725. (3) During the spring of 1898 extensive areas northward of Round Island Shoals were worked over by the sweeping raft, with bars hung at a depth of 25 feet, for the purpose of ascertaining whether any unknown obstructions existed in that locality. (4) During May, 1898, the channel dredged through Grosse Pointe Flats was examined and sounded in part, and several points in St. Clair River were surveyed, developing eleven small but troublesome shoals. It is proposed to remove these obstructions and shoals during the present working season. (5) During October and November systematic soundings, 10 feet apart, were taken at Lime Kiln Crossing, Detroit River, to show its condition and project further improvement. This survey developed many points with scant 18 feet of water over them, instead of showing the clear depth of 20 feet that was supposed to exist. As a result of this discovery, 583 tons of bowlders and loose rock were removed from that channel in March and April, 1898, by day-labor, thereby increasing the available depth to 19 feet. (6) During February, 1898, an ice survey was made covering the area worked over during the season of 1897 by L. P. & J. A. Smith, contractors, for improving the bar at the mouth of Detroit River. The soundings were taken at intervals of 10 feet on cross-sectional lines 20 feet apart, and covered an area 7,000 feet long by 600 feet wide.

The total expenditure to June 30, 1898, was $2,507,121.40, of which $294,609.05 were spent during the last fiscal year. The total excavation to that date was 9,955,447 cubic yards, of which 312,267 cubic yards were removed during the last fiscal year. The maximum available depth over the shoalest part of the ship channel was 18 feet, this depth being found only in the lower section of Detroit River; all other sections of the ship channel have a clear depth of 20 feet or more.

The work of most immediate importance on this improvement is the completion of that now in progress on the Lower Detroit River, and funds available will probably be sufficient to obtain a 20-foot channel there with a minimum width of 300 feet, but it will have five turns in it in a distance of 4½ miles, and safe navigation requires that the least width should be 600 feet. Channels already made with less than that width should be widened at all critical points, and all detached shoals that may be found in or near the line of through travel should be promptly removed. Several have already been found by our surveys or examinations, or by vessels loaded to the deeper draft now carried as

a result of recent improvements, and it is highly probable that others will be developed in the same way. Further, the sundry act of June 4, 1897, requires that "necessary observations and in gations in connection with the preservation of such channel d (20 or 21 feet) be made, and authorizes expenditure for that pu from appropriation for work on the ship channel.

The balance of funds available for continuing operations is $607,1 and it is certain that further appropriation will be required for all that is indicated above; but, under requirements of law and lations, estimate is withheld until duly called for by Congress.

The observations and investigations referred to above are not of vital importance in relation to this particular work, but every and harbor improvement on the lakes and their connecting chann deeply concerned in them. The cost of making them comprehensiv complete enough to supply data for reliable conclusions as to wl needed for the preservation of these channel and harbor depths wi be less than $250,000, and an expenditure of at least twice that will be required for such extended work as is urgently neede obtaining a reasonably accurate knowledge of the physical condi which control and regulate the levels of this great water systen would therefore seem highly proper that provision for completing observations and investigations should be made elsewhere than i appropriation for this specific improvement, and the propriety of ing it in connection with the appropriation for surveys of the Nor and Northwestern Lakes is suggested for consideration. Most a precise work of that nature heretofore done has been in connection these surveys.

Money statement.

July 1, 1897, balance unexpended		$1,130,
June 30, 1898, amount expended during fiscal year, including 48 cents paid by Treasury Department, account Western Union Telegraph Company		294,
July 1, 1898, balance unexpended		835,
July 1, 1898, outstanding liabilities	$35,461.81	
July 1, 1898, amount covered by uncompleted contracts	193,073.50	
		228,
July 1, 1898, balance available		607,

Appropriations for ship channel in the connecting waters of the Great Lakes.

July 13, 1892	$375,(
March 3, 1893, sundry civil act	875,(
March 2, 1895, sundry civil act	500,(
June 11, 1896, sundry civil act	500,(
June 4, 1897, sundry civil act	1,090,(
Total	3,340,(
February 19, 1895, repayment of overpayment made R. J. Cram, dredging section 1	2,

Abstract of proposals for dredging and submarine rock excavation in the St. Marys River, Michigan (Items A and B), received in response to advertisement dated August 2, 1897, and opened August 31, 1897.

Name and address of bidder.	Per cubic yard, bank measurement.	
	Item A.	Item B.
M. Sullivan, Detroit, Mich	$0.98	a $0.52
G. H. Breymann & Bros., Toledo, Ohio	.44	.54
Hingston & Woods, Buffalo, N. Y	.52	.60
The L. P. & J. A. Smith Co., Cleveland, Ohio	.60	.60
James Rooney, Toledo, Ohio	.60	.60
Joseph R. McCollum, Port Huron, Mich	.44	.62
Carkin, Stickney & Cram, Detroit, Mich	.44	.67
William A. Starke, Milwaukee, Wis	.....	.73
H. W. Hubbell & Co., Saginaw, Mich	.....	.74
Arthur H. Vogel, Milwaukee, Wis	a .34	.75
Lydon & Drews Co., Chicago, Ill	.40	.76
C. E. Mitchell & Co., Ludington, Mich	.48	.77
Hickler Bros., Sault Ste. Marie, Mich	1.00	.78
F. M. Knapp, Racine, Wis	.50	.87

a Contracts entered into Sept. 13, 1897.

Abstract of proposals for removing obstructions, Grosse Isle Lower Range, received in response to advertisement dated April 1, 1898, and opened April 21, 1898.

Name and address of bidder.	15,000 net tons of 2,000 pounds.		36,000 cubic yards.		Aggregate.
	Rate.	Total.	Rate.	Total.	
M. Sullivan, Detroit, Mich. a	$2.60	$39,000	$2.15	$64,500	$103,500
Carkin, Stickney & Cram, Detroit, Mich	1.97	29,550	2.95	88,500	118,050
James Rooney, Toledo, Ohio	2.15	32,250	3.20	96,000	128,250
G. H. & J. B. Breymann, Toledo, Ohio	2.25	33,750	3.50	105,000	138,750
The L. P. & J. A. Smith Co., Cleveland, Ohio	2.80	42,000	4.15	124,500	166,500
W. A. McGillis & Co., Cleveland, Ohio	3.50	52,500	5.25	157,500	210,000

a Contract entered into Apr. 28, 1898.

Abstract of proposals for furnishing and operating dredging plant from foot of Limekiln Crossing to mouth of Detroit River, received in response to advertisement dated April 1, 1898, and opened April 21, 1898.

Name and address of bidder.	Per hour.
James Rooney, Toledo, Ohio a	$9.00
G. H. & J. B. Breymann, Toledo, Ohio	10.00
Joseph R. McCollum, Port Huron, Mich	11.00
W. A. McGillis & Co., Cleveland, Ohio	11.25
Carkin, Stickney & Cram, Detroit, Mich	15.00
The L. P. & J. A. Smith Co., Cleveland, Ohio	15.00

a Contract entered into May 2, 1898.

Abstract of contracts in force.

Name of contractor.	Date of approval.	Date of beginning.	Date of expiration.
L. P. & J. A. Smith a	Jan. 19, 1893	June 1, 1893	July 1, 1897
W. A. McGillis & Co. b	Oct. 24, 1895	Sept. 4, 1896	July 10, 1897
Arthur H. Vogel	Sept. 22, 1897	Sept. 27, 1897	Oct. 31, 1898
Michael Sullivan	Oct. 13, 1897	Sept. 21, 1897	Dec. 31, 1898
Do	May 9, 1898	May 3, 1898	Dec. 1, 1898
James Rooney	May 14, 1898	May 23, 1898	Indefinite.

a Completed Oct. 28, 1897. b Completed Oct. 15, 1897.

L L 2.

IMPROVEMENT OF ST. MARYS RIVER AT THE FALLS, MICHIGAN.

At the time of the adoption of the present project the old State locks, built in 1855, and the lock of 1881 were in operation, giving, at the normal stage of water, a maximum draft of about 16 feet. To meet the demands of the large and rapidly increasing commerce between Lake Superior and the lower lakes a lock of greater capacity and an increased allowable draft was urgently required.

The project thereupon presented October 18, 1886, provided, as its leading features, for constructing a new lock 100 feet wide and 800 feet long between gates, with a single lift of 18 to 20 feet according to the fluctuation of the upper and lower levels, and depth of 21 feet over the miter sills; the canal and its approaches to be deepened to correspond. The estimated cost was $4,738,865. Details of the project and estimate are published in the Annual Report of the Chief of Engineers for 1887 (pp. 2220–2223); an outline of operations to June 30, 1896, in report for that year (pp. 2779–2784), and of their continuation to June 30, 1897, in report for that year (pp. 2963–2965). The new lock was opened to navigation August 3, 1896.

Operations during the last fiscal year comprised: (1) Work on the west approach to the canal, under contract with Dunbar & Sullivan, of Buffalo, N. Y., dated September 14, 1895, to provide a channel 600 feet wide and 21 feet deep. Work under this contract had been commenced October 28, 1895, and was completed July 20, 1897, the total excavation being 165,101.3 cubic yards, bank measure. (2) Work in continuation of the above under contract with H. W. Hubbell & Co., of Saginaw, Mich., dated September 13, 1897, to increase the width of channel to 1,000 feet. Operations commenced October 7, 1897, and were still in progress at the close of the fiscal year, the amount excavated in the meantime being 39,263 cubic yards, scow measure. (3) Removing sill of old movable dam and deepening canal in the vicinity to 25 feet, under contract made with Hickler Brothers, of Sault Ste. Marie, Mich., after public notice dated March 17, 1898. Work was commenced April 4 and completed June 27, 1898, the amount of material drilled, blasted, and removed comprising timber work, concrete, and solid rock in situ being 4,082.6 cubic yards, bank measure. (4) Building safety gates in canal to replace old movable dam. The masonry side walls and miter sill, together with all other under-water work was done while navigation was suspended between December 10, 1897, and March 8, 1898, and the construction of the gates was practically completed at the end of the fiscal year. (5) The new power house and office building, under contract with Joseph Vernon Gearing, of Detroit, Mich., dated August 11, 1894, was completed September 17, 1897.

The details of operations involved in items 1, 2, and 3 of the foregoing paragraph are given in the following report prepared by Mr. Benno Rohnert, and those concerning items 4 and 5 in that prepared by Mr. J. L. Callard, assistant engineers in immediate charge of the several works.

REPORT OF MR. BENNO ROHNERT, ASSISTANT ENGINEER.

Item A (west approach to canal; channel 600 feet wide through Vidal Shoals).—Contract dated September 14, 1895; Dunbar & Sullivan, Buffalo, N. Y., contractors. Rates, 28 cents per cubic yard, bank measure, for earth, and $10 per cubic yard for

rock to 21-foot grade, and half rates between 21 and 23 feet. Material, sand, bowlders, and sandstone rock in situ. The contractors began work on this section October 28, 1895.

Work was continued during July with one dredge and one diving outfit, removing such points as remained above grade. The dredge worked 29 hours, was delayed 16 hours, and excavated 70 cubic yards, scow measure. The diver worked 165 hours and raised 175 cubic yards. The section was swept and found clear July 20. The summary sheets of computations for final estimate were submitted September 14. The computations were made in duplicate. The computed bank measure of material from above the 21-foot grade is 81,338.4, of which 2,000 were paid for as rock; between 21 and 23 foot grades, 54,630.9; below the 23-foot grade and outside of side slopes, 29,132, making a total of 165,101.3 cubic yards. The total cost of excavation is $49,863.08. When bed rock was found in the lower shoal, a portion was set apart for the contractors, from which they could take 2,000 cubic yards, this being the maximum amount of rock to be excavated under their contract. Any excess was to be paid for as earth. From the portion set aside the bowlders and earth were stripped, and soundings, 10 feet apart both longitudinally and transversely, were taken over the area. The survey was repeated after the cut had been made. The actual quantity of rock excavated by the contractors, and in bank measure, is 2,073.8 cubic yards above 21-foot grade; between 21 and 23 foot grades, 1,070.1; below 23-foot grade and outside of side slopes, 938.7, making a total of 4,082.6 cubic yards.

This improvement was not available to navigation until the rock shoal, which extended more than two-thirds across the channel, was removed under a new contract.

Item C (shoals, west approach to canal; channel, 1,000 feet wide, through Vidal Shoals).—Contract dated September 13, 1897; H. W. Hubbell & Co., contractors, Saginaw, Mich. Rates, 94 cents per cubic yard, bank measure, for all material above 21-foot grade, and half rates between 21 and 23 foot grades. Material, sand, bowlders, and sandstone rock in situ.

The contractors began work on October 2 and, save between October 10 and November 2, continued until December 24, when the plant was laid up for the winter season. Operations were resumed April 9. The dredge worked 1,309¼ hours, was delayed 382$\frac{3}{4}$ hours, and excavated 39,263 cubic yards, scow measure, of material. A diver's outfit was in commission from June 1 to 7. During the 55 hours the diver worked 59 cubic yards of bowlders, which projected above the 19-foot grade, were removed.

During May it was reported that vessels were striking in the channel through Vidal Shoals then in use. A careful examination with raft bars was made and established the fact that the grade had not been impaired, but the draft had been materially diminished on account of the low stage of water in Lake Superior, 1 foot below mean on the day of sweeping. Temporary improvements were not made because they were too extensive and an early completion of a 300-foot channel through the new improvement was expected. Several sweepings of the 300-foot cut were made with the final result that the contractor had obtained an actual depth of 18 feet of water on June 4. On June 8 it was buoyed and lighted and thrown open to navigation. The first vessels bound up were the *J. J. McWilliams* and *Alberta*, drawing, respectively, 16 feet 3 inches and 14 feet 6 inches; bound down, *Harlem* and *J. W. Nicholas*, 16 feet and 17 feet 2 inches. The Government tugs *Antelope* and *Myra* were temporarily stationed at the shoals to pilot boats through the cut, to inform masters as to location, marking, etc.

Removal of material from site of morable dam, St. Marys Falls Canal—Deepening to 25 feet.—Public notice dated March 17, 1898; Hickler Brothers, of Sault Ste. Marie, Mich., contractors; rates, $6.50 per cubic yard, bank measure, for all material to 25-foot grade and half rates between 25 and 26 feet; material, sandstone rock in situ, timber, concrete, and iron bolts.

The cutting off of timbers 3 inches from the face of the masonry, which was built upon them, was begun April 4, and continued until April 9, when all the work that could be done in the day and while the dam was closed was finished. Each timber, 12 by 12 inches, was bored with five holes. From April 10 to 13 a diver completed the borings above the dam. On April 13 one drill and one dredge began work. The record of drill is 157¾ hours worked, 87 delayed, 204 holes drilled, and 1,961¼ pounds of 50 per cent dynamite used in blasting. The total depth of holes drilled is 1,697 feet. The dredge worked 161¾ hours, was delayed 43¼ hours, and excavated 3,995 cubic yards, scow measure, of material. The drill stopped April 28 and the dredge April 21. On April 29 the diver began picking up all material left above the 25-foot grade, and, in the catch-basin, excavated for the new safety gates. This work was continued till June 27. Including the work in the day, the diver worked 578 hours, was delayed 59 hours, raised 710 cubic yards of material, bored 358 holes, and used

50 pounds of powder. On June 27 the examination with raft bars as to grade, and by diver as to cleaning catch-basin, was made, and showed that the work was finished. The duplicate computations of the amount of material removed were made, with the following result: From above the 25-foot grade, 2,444.6 cubic yards, bank measure; between 25 and 26 feet, 383.6; below 26 feet, 309.1, making a total bank measure of 3,137.3 cubic yards. This improvement finished gives a draft of 25 feet from the Poe Lock to westerly entrance of the canal.

REPORT OF MR. J. L. CALLARD, ASSISTANT ENGINEER.

Canal safety gates.—The site of these gates is east of and adjacent to the masonry abutments of the movable dam. The canal at that point is 108 feet wide in the clear. The distance between the centers of figure, also the centers of revolution, of the heel post of the gate is 114 feet. The gate is of the circular-arch type, the chord of each leaf being 60.658 feet long; the radius of the neutral axis of the arch is 98.147 feet, it is 31.67 feet high, and designed to withstand a pressure due to 27 feet of water over the sill, and is constructed of Oregon fir.

The timber and iron for the gate were furnished by Hickler Brothers, of Sault Ste. Marie, Mich. The cement was furnished by the Sandusky Portland Cement Company, of Sandusky, Ohio, The stone used for the concrete abutments, recesses, etc., was limestone chips, the refuse from the stone planers used in dressing the cut stone for the Poe Lock and owned by the United States. The sand was pumped from the bottom of the river near the shore at Pointe Aux Pins.

The work of excavating, laying the concrete, and building the gate was done by the United States.

The plant used consisted of the United States pump scow, furnished with two 15-inch centrifugal pumps, engines, and boilers, one 10-inch Cameron pump, two derrick engines, two boilers, two derricks, three steam drills, fourteen derrick boxes, wheelbarrows, picks, shovels, etc. With the exception of the derrick engines and steam drills, which were rented, and the two derricks, which were built especially for this work, the United States had the above plant on hand.

The following temporary buildings were erected: Two sheds, for concrete mixing, one on either side of the canal, each 64 feet long and 28 feet wide, parts of which were divided into bins provided with steam coils for heating the frozen sand and stone previous to making into concrete, one boiler house, two engine houses, one powder magazine, and a small building for warming the powder.

The cost of the plant to June 30 was, for—

Labor	$1,942.43
Materials and repairs	1,989.06
Total	3,931.49

The cost of the repairs to the pump scow alone was $652.90; the boiler had to be furnished with a new set of tubes and a smokestack before it could be used. Included in the cost of the plant is the cost of the several sheds built.

The movable dam was closed on December 10. The sill of the dam had been considerably damaged by the keels of heavily laden vessels dragging over it, which had to be repaired by divers. These repairs, together with other repairs to the dam during the winter, cost $860.60. The repairs to the sill were completed and the water let out of that part of the canal east of the movable dam to the level of the valves in the guard-gate miter wall of the Poe Lock on December 17. The water remaining in the canal below this level had to be pumped out. The pumps on the pump scow were used for this purpose, the scow resting upon the downstream apron of the sill foundation of the movable dam, the water being pumped over the top of the dam into the pool above. The leakage of water through the dam and sides of the canal, which was considerable, was also pumped over the dam.

The cost of pumping was, for—

Labor	$1,014.01
Repairs, oil, etc.	70.58
Total	1,084.59
The cost of fuel for pumping and all other purposes was (740$\frac{8}{2000}$ tons)	2,076.33

The work of excavating was begun as soon as the water was let out of the canal and completed on January 20, 1898. About 3.900 cubic yards of rock and 1,100 cubic yards of earth and timber pier were excavated. The excavating was done by two shifts of men, each shift working eight hours.

The cost of excavating was, for—

Labor	$4,847.42
Explosives, fuses, etc	506.05
Sharpening drills and repairing tools	306.17
Lights and sundries	46.85
Total	5,706.49

On the completion of the excavation the work of erecting the timber forms for the faces of the concrete walls of the gate abutments and recesses was begun.

From February 1 to 21 all work, except pumping, was suspended on account of the failure of the contractor to furnish the eye bars for the anchorage system, which had to be built into the concrete abutments.

The eye bars having arrived the work of laying the concrete for the abutments and recesses was begun on the morning of March 1 and completed on the evening of March 7. This part of the work was made continuous by the employment of three shifts of men, each shift working eight hours, less fifteen minutes for lunch. The concrete for the foundation for the miter-sill was laid later in the month. The concrete for the gate abutments and recesses was composed of 1 part cement, 1 part sand, and 6 parts limestone planer chips; that for the foundation of the miter-sill of 1 part cement, 1 part sand, and 5 parts limestone planer chips.

To remove the frost from the sand and stone before using it was necessary to place it in bins heated with steam coils, and the water used for mixing the concrete was warmed with a jet of steam. There were laid in all about 1,300 cubic yards of concrete, of which about 1,200 cubic yards were laid in the gate abutments and recesses, and about 100 cubic yards in the foundation for the miter-sill.

No foundations are yet laid for the operating machinery and the coping is not completed; to do this will require about 100 cubic yards of concrete.

The cost of laying the concrete was, for—

Labor	$3,101.64
Materials	5,515.04
Total	8,616.68

Under the cost of labor is included $850.63 for transferring about 1,200 cubic yards of planer chips, by scow, from Fort Brady Pier to the site of canal gate. The extra labor of putting the stone and sand in bins to remove the frost added considerably to the cost of mixing. Included in the cost of materials is $1,147.60, the cost of 412 barrels of cement at $2.30 per barrel, and about 200 cubic yards of sand at $1 per cubic yard, which were not used, but which were purchased for this work.

It was designed to build the gate in place before the opening of navigation, but on account of contractors failing to deliver the iron and timber in time it had to be built on the canal bank. This part of the work will be completed in six or eight days.

The cost of the gate to date is, for—

Labor	$1,878.63
Timber	3,705.88
Iron	5,497.31
Oil, white lead, etc	135.13
Total	11,216.95

Included in the cost of the gate is $287.50, the cost of the timber in the sill and the labor of framing the same, and about $400, the cost of the timber not used, but which was purchased for the gate; also $1,249.18, the cost of the iron in the anchorage system, etc.

About $200 will pay for the labor of completing the building of the gate after June 30. The launching and putting it in place will probably cost about $500.

Besides the above classified expenditure of labor there was $939.66 expended on labor for miscellaneous work, such as drilling for the fox bolts for bolting miter sill, placing fenders on face of gate abutments, building temporary floating fenders for gate recesses, etc. The cost of engineering and superintendence to June 30 is $3,041.17.

Summary of cost to June 30.

Plant	$3,931.49
Pumping	1,084.59
Fuel	2,076.33
Movable dam	860.60
Excavation	5,706.49
Concrete	8,616.68
Gate	11,216.95
Engineering and superintendence	3,041.17
Miscellaneous	939.66
Total	37,338.83

Power-house and office building.—Very little work remained to be done on the building at the close of the last fiscal year. The electric-lighting plant was completed and the required tests made during the month of July. The elevator was completed and the required tests made, and the marble base and mosaic floor completed during the month of August. All the remaining work under this contract was completed before September 17, and the keys of the building were turned over to a representative of the United States on that date.

Surveys and examinations were made as required to show the condition of improvements completed or in progress, develop shoals or other obstructions to navigation, project further improvements, and locate range lights, targets, buoys, and other aids to navigation, all as described in the following extract from report prepared by Assistant Engineer Benno Rohnert, in charge:

Triangulation stations.—Two were destroyed. Triangulation station 10, which was located on a sandy point opposite to and in a northerly direction from Round Island, was washed out of position. The station was replaced close to its old position to save heavy cutting of timber, and was surrounded by cribbing made from such drift logs as could be procured from the neighboring beach. Triangulation station R. I. L. H., which was located on the platform of the tower of Round Island Lighthouse was destroyed by the removal of the upper works of said tower. The new station is in a northerly direction from the old one and on a granite bowlder, marked "△ R. I." The new stations were read in from triangulation stations 12 and 15, and their rectangular coordinates, referred to triangulation station 11, survey of 1879, are—

△ 10 R. 943.68 west, 13,079.69 north.
△ R. I. 1,509.47 west, 3,689.51 north.

Sweeping with raft.—Besides the regular work required in proving up contracts, the river from the canal to the upper entrance of Hay Lake Channel was swept for 21 feet below the established plane of mean water surface. No obstruction was found except at Sprys Shoal, which was improved to 20 feet. Also from the canal to Vidal Shoals, where a small shoal was found. A survey of that part which projects south of the north line of Item C was made.

Range lights, targets, buoys, etc.—The private range targets and lights in the vicinity of Point aux Frênes were read in. Their rectangular coordinates, referred to triangulation station Winter Point, were computed. A list of azimuths and distances of all range lights, targets, channel buoys, crib lights, etc., marking the navigable channels of St. Marys River from Iriquois Point to Point aux Frênes, was prepared and submitted.

Surveys.—Such changes as have occurred during the year in the canal grounds or immediate vicinity were surveyed. The approved harbor line was staked out for the Port Royal Dock Company, who extended their pier to said line.

The following areas were sounded: Site of proposed extension to northeast pier of Poe Lock; Item C, for season's estimates of 1897; shoal found about 1,000 to 1,500 feet west of lighthouse of southwest canal pier and site of movable dam; 7,650 soundings were taken, of which 4,790 were in the winter, through the ice. For this purpose, and for the guidance of contractors, 95 section stakes and 3 gauge boards were driven, and 8 gauge boards were placed. Azimuths from 2 triangulation stations to 12 stakes were computed. All soundings were reduced and mapped on tracing linen or platted on cross-section sheets, as necessity required.

Tests were made of deflections of the lower lock gates of the Poe and Weitzel Locks and the leakage of the valves of the Weitzel Lock.

Water levels.—Daily water-gauge readings above and below the locks were continued during the year, and the annual mean for the

calendar year 1897 and the monthly means for the various months have been computed. In order that these published tables may be kept up to date, the various monthly and annual means of St. Marys River, above and below the locks and Lake Huron are submitted herewith.

Elevation above sea level.

Month.	St. Marys River.		Lake Huron.
	Above the locks.	Below the locks.	
1897.			
July	602.50	533.00	580.39
August	602.65	583.17	580.40
September	602.49	582.97	580.14
October	602.27	582.68	579.79
November	602.17	582.36	579.67
December	601.68	582.14	579.37
Annual mean (calendar year)	602.01	582.57	579.69
1898.			
January	601.18	582.37	579.22
February	600.96	582.55	579.28
March	600.80	582.18	579.51
April	601.04	581.70	580.00
May	601.22	581.98	580.12
June	601.64	582.36	580.28

NOTE.—To obtain the elevation of Lake Superior, the fall of the river between Whitefish Bay and the canal should be added to these readings taken above the locks. This fall for the normal stage is about 0.41 foot. The elevations heretofore published as those of Lake Superior are the readings taken in the St. Marys River above the locks, and should be similarly corrected to obtain the elevations of Lake Superior proper. The elevations of the gauges are derived from bench mark 2, on the south wall of the lock of 1881, established by the United States Lake Survey in 1867 by water-level observations. The elevation of the bench mark is 605.87 feet above mean tide at New York.

Differences in elevation.

Month.	Between St. Marys River above and below the locks.	Between St. Marys River below the locks and Lake Huron.	Between St. Marys River above the locks and Lake Huron.
1897.			
July	19.50	2.61	22.11
August	19.48	2.77	22.15
September	19.52	2.83	22.35
October	19.59	2.89	22.48
November	19.81	2.69	22.50
December	19.53	2.77	22.31
Annual mean (calender year)	19.43	2.88	22.30
1898.			
January	18.81	3.15	21.96
February	18.41	3.27	21.68
March	18.63	2.67	21.29
April	19.34	1.70	21.04
May	19.24	1.86	21.10
June	19.28	2.08	21.36

The estimated cost of this improvement was $4,738,865, all of which has been appropriated. In addition to this, $25,000 was appropriated by act of March 3, 1893, for improving the Lake George Channel, making the total appropriation to date $4,763,865. The improvements in Lake George were duly made, and the balance of money now available will suffice for completing the work that remains to be done in connection with the canal system at the falls.

The commerce passing through the St. Marys River, as shown by the

accurate statistics of traffic through both the Canadian and Ame locks at the Sault for the navigable season of 1897, a period o days, was 18,982,755 tons of freight, valued at $218,235,927.77. number of passengers reported on vessels in transit through the was 40,213.

The work is in the collection district of Superior, Mich. The nearest port of is Marquette, but Sault Ste. Marie is a subport. The nearest light houses a beacons on the western end of the canal, and Fort Brady is within a mile.

Total expenditure to June 30, 1897	$3,561,
Expended during fiscal year, excluding outstanding liabilities	141,
Total expenditure to June 30, 1898	3,703,

Money statement.

July 1, 1897, balance unexpended		$1,201,
June 30, 1898, amount expended during fiscal year, including 20 cents paid by Treasury Department, account Western Union Telegraph Company		141,
July 1, 1898, balance unexpended		1,060,
July 1, 1898, outstanding liabilities	$49,366.96	
July 1, 1898, amount covered by uncompleted contracts	28,645.84	
		78,
July 1, 1898, balance available		982,

Appropriations for improving St. Marys River, Michigan.

August 5, 1886	$250,
August 11, 1888	1,000,
September 19, 1890	900,
March 3, 1891, sundry civil act	600,
March 3, 1893, sundry civil act	1,230,
August 18, 1894, sundry civil act	300,
March 2, 1895, sundry civil act	483,
Total	4,763,

Receipts from sales of fuel to officers, January, May, and June, 1887..
Repayment of disallowance of part voucher 19, August, 1894 (see p. 2895, Report Chief of Engineers, 1894)
Repayment of disallowance of part voucher 24, September, 1896.....

Abstract of proposals for dredging and submarine rock excavation in the St. Marys Michigan (Item C), received in response to advertisement dated August 2, 189 opened August 31, 1897.

Name and address of bidder.	Per yar mo n
H. W. Hubbell & Co., Saginaw Mich. a	
Hingston & Woods, Buffalo, N. Y	
M. Sullivan, Detroit, Mich	
Hickler Brothers, Sault Ste. Marie, Mich	
William A. Starke, Milwaukee, Wis	
Lydon & Drews Co., Chicago, Ill	
G. H. Breymann & Brothers, Toledo, Ohio	
Arthur H. Vogel, Milwaukee, Wis	
Carkin, Stickney & Cram, Detroit, Mich	
The L. P. & J. A. Smith Co., Cleveland, Ohio	

a Contract entered into September 13, 1897.

Abstract of contracts in force.

Name of contractor.	Date of approval.	Date of beginning.	Date of expiration.
Joseph Vernon Gearing a	Aug. 21, 1894	Sept. 11, 1894	July 1, 1897
Dunbar & Sullivan b	Oct. 19, 1895	Oct. 28, 1895	Do.
H. W. Hubbell & Co	Sept. 21, 1897	Oct. 2, 1897	Sept. 30, 1898

a Completed September 27, 1897. b Completed July 20, 1897.

L L 3.

OPERATING AND CARE OF ST. MARYS FALLS CANAL, MICHIGAN.

This is provided for by the permanent indefinite appropriation for operating and care of canals and other works of navigation under section 4 of the river and harbor act of July 5, 1884, and the amount expended for it during the fiscal year ending June 30, 1898, was $58,890.72.

During the year the Poe and Weitzel locks were both in service, with a regular operating force, as finally organized, of 1 superintendent and 3 assistant superintendents, with 63 men, working in three watches of eight hours duration daily. This was an increase of 7 in the number of men for each watch, in order to operate both locks, and thereby provide for safe and expeditious passage of the steadily growing commerce. In addition to this force a labor party of varying size, as required for the care and repair of the canal and the grounds pertaining to it, served under the immediate direction of the assistant engineer and general superintendent.

The canal was opened to navigation 237 days, the closed season being between December 10, 1897, and April 18, 1898, and during that period considerable repairs and modifications were made in some of the details of the Poe Lock machinery. The beneficial effects of this work have been plainly apparent since navigation was resumed last spring. The timber walls of this lock were also repaired and strengthened during the closed season, and extensive repairs were made to the lower gates of the Weitzel lock to make them safe for another year's service.

The total delays that occurred during the year in locking vessels were 99 hours, of which 6½ were in the Weitzel and 92½ in the Poe lock, and of the latter 90 occurred between July 1 and December 10, 1897, being an average of about 16½ hours per month for that period. This average fell to 1 hour per month after the completion of repairs above referred to from the resumption of navigation in April, 1898, to the close of the fiscal year.

On the outbreak of war with Spain a special guard of twenty-four deputy sheriffs was established at the locks and continued in service to June 27, after which this duty was performed by a detail from the adjoining military garrison at Fort Brady, Mich. (Eighteenth Pennsylvania Volunteers).

The number of vessel passages through these locks during the last fiscal year was 13,411, their registry aggregating 14,435,068 tons, the freight carried by them 14,968,377 tons, and the number of passengers 28,767. During the same period the number of vessel passages through the Canadian lock was 4,750, carrying 5,320,262 tons of freight

and 11,883 passengers; the combined traffic through the two showing the total Lake Superior commerce to have comprised vessel passages, with 20,288,639 tons of freight and 40,650 passe This is an increase in the number of passages of 9 per cent, b increase in the freight traffic reached the phenomenal proportior per cent, and of the passenger service 38 per cent. The tables below present many other interesting details concerning this commerce.

The canal post-office handled 82,179 pieces of mail, consist 71,840 letters, 4,326 postal cards, 5,700 newspapers, and 313 parce addition to this, 598 pieces were returned to the city post-offic being held thirty days uncalled for, and 1,346 pieces were forw to new addresses. This mail service shows a slight decrease a pared with the previous year.

The following statements and tables give interesting details traffic through this canal and its companion on the Canadian s the fiscal year ending June 30, 1898, thereby showing the total traffic to and from Lake Superior for that period:

No. 1.—*Statement of the number of vessels passing through St. Marys Falls Michigan, with number and cost of lockage, for the fiscal year ending June 30,*

Number of vessels through Weitzel Lock, 2,778; through Poe Lock, 10,633; of lockages through Weitzel Lock, 1,660; through Poe Lock, 4,598; total reg tonnage, 14,435,068; total freight tonnage, 14,968,377; total time during whic were operated, 4,172 hours 26 minutes; average time occupied in making a l 40 minutes; total time spent by vessels in passing locks, 8,115 hours 23 m average time spent by vessels in passing locks, 36 minutes 31 seconds; c lockage, $9.41; cost per passage, $4.39; cost per registered ton, 4.08 mills; c freight ton, 3.93 mills.

The United States canal was open to navigation 237 days, from July 1 to De 10, 1897, and from April 18 to June 30, 1898, and the Canadian canal was o days.

No. 2.—*Statement of total commerce to and from Lake Superior for the fiscal yea June 30, 1898, through United States and Canadian canals at Sault Ste. Marie and Sault Ste. Marie, Ontario.*

Items.	United States canal.	Canadian canal.	T
Vessels.....number..	13,411	4,750	
Lockages.....do....	6,258	2,964	
Tonnage, registered.....net tons..	14,435,068	4,114,797	1
Tonnage, freight.....do....	14,968,377	5,320,262	2
Passengers.....number..	28,767	11,883	
Coal, hard.....net tons..	445,216	105,460	
Coal, soft.....do....	2,299,212	483,187	
Flour.....barrels..	7,310,407	1,138,945	
Wheat.....bushels..	31,717,055	16,209,721	4
Grain.....do....	19,665,790	4,241,342	2
Manufactured and pig iron.....net tons..	159,754	25,411	
Salt.....barrels..	287,877	39,235	
Copper.....net tons..	115,260	8,218	
Iron ore.....do....	7,948,577	3,840,776	1
Lumber.....M. feet B. M..	808,607	14,846	
Silver ore.....net tons..	5	.....	
Building stone.....do....	7,506	.....	
Unclassified freight.....do....	517,941	92,921	

NOTE.—The United States canal was open to commerce during the fiscal year 237 days, fro to December 10, 1897, and from April 18 to June 30, 1898.

The Canadian canal was open to commerce during the fiscal year 248 days, from July 1 to D 14, 1897, and from April 11 to June 30, 1898. All dates inclusive.

No. 3.—*Comparative statement of total commerce to and from Lake Superior for the fiscal years 1897 and 1898, through United States and Canadian canals at Sault Ste. Marie, Mich. and Ontario.*

Items.	Fiscal year.		Increase.	Decrease.
	1897.	1898.		
Vessels.....number..	16,841	18,161	1,320	.....
Lockages.....do....	8,497	9,222	725	.....
Tonnage, registered.....net tons..	15,933,343	18,549,865	2,616,522	.....
Tonnage, freight.....do....	15,817,577	20,288,639	4,471,062	.....
Passengers.....number..	34,019	40,650	6,631	.....
Coal.....net tons..	2,935,827	3,333,075	397,248	.....
Flour.....barrels..	9,397,860	8,449,352	.....	948,508
Wheat.....bushels..	59,895,987	47,926,776	.....	11,969,211
Grain, other than wheat.....do....	31,550,694	23,907,132	.....	7,643,562
Manufactured and pig iron.....net tons..	122,057	185,165	63,108	.....
Salt.....barrels..	227,204	327,112	99,908	.....
Copper.....net tons..	119,986	123,478	3,492	.....
Iron ore.....do....	5,544,457	11,789,353	6,244,896	.....
Lumber.....M feet B. M..	682,453	823,453	141,000	.....
Silver ore.....net tons..	240	5	.....	235
Building stone.....do....	14,519	7,506	.....	7,013
Unclassified freight.....do....	538,945	610,862	71,917	.....

No. 4.—*Comparative statement of commerce through St. Marys Falls Canal, Michigan, for the fiscal years 1897 and 1898.*

Items.	Fiscal year.		Increase.	Decrease.
	1897.	1898.		
Vessels.....number..	12,291	13,411	1,120	.....
Lockages.....do....	5,780	6,258	478	.....
Tonnage, registered.....net tons..	12,277,458	14,435,068	2,157,610	.....
Tonnage, freight.....do....	11,827,359	14,968,377	3,141,018	.....
Passengers.....number..	20,900	28,767	7,867	.....
Coal.....net tons..	2,064,270	2,744,428	680,158	.....
Flour.....barrels..	7,733,707	7,310,407	.....	423,300
Wheat.....bushels..	41,799,722	31,717,055	.....	10,082,667
Grain, other than wheat.....do....	26,964,541	19,665,790	.....	7,298,751
Manufactured and pig iron.....net tons..	107,036	159,754	52,718	.....
Salt.....barrels..	215,254	287,877	72,623	.....
Copper.....net tons..	110,746	115,260	4,514	.....
Iron ore.....do....	5,414,188	7,948,577	2,534,389	.....
Lumber.....M feet B. M..	664,123	808,607	144,484	.....
Silver ore.....net tons..	240	5	.....	235
Building stone.....do....	14,459	7,506	.....	6,953
Unclassified freight.....do....	441,122	517,941	76,819	.....

No. 5.—*Comparative statement of commerce through Canadian Canal, Ontario, for the fiscal years 1897 and 1898.*

Items.	Fiscal year.		Increase.	Decrease.
	1897.	1898.		
Vessels.....number..	4,550	4,750	200	.....
Lockages.....do....	2,717	2,964	247	.....
Tonnage, registered.....net tons..	3,655,885	4,114,797	458,912	.....
Tonnage, freight.....do....	3,990,218	5,320,262	1,330,044	.....
Passengers.....number..	13,110	11,883	.....	1,227
Coal.....net tons..	871,557	588,647	.....	282,910
Flour.....barrels..	1,664,153	1,138,945	.....	525,208
Wheat.....bushels..	18,096,265	16,209,721	.....	1,886,544
Grain, other than wheat.....do....	4,586,153	4,241,342	.....	344,811
Manufactured and pig iron.....net tons..	15,021	25,411	10,390	.....
Salt.....barrels..	11,950	39,235	27,285	.....
Copper.....net tons..	9,240	8,218	.....	1,022
Iron ore.....do....	2,130,269	3,840,776	1,710,507	.....
Lumber.....M feet B. M..	18,330	14,846	.....	3,484
Building stone.....net tons..	60	.....	.....	60
Unclassified freight.....do....	97,823	92,921	.....	4,902

Special attention is invited to the fact that the foregoing statistics relate to the fiscal years, and that the continuity of record for a complete single season of navigation is thereby broken; for example, the statistics for the fiscal year 1897 comprise only the latter part of the navigable season of 1897 (July 1 to December, 1897) and the first part of the navigable season of 1898 (April to July 1, 1898). The following reports and tables, made up for calendar years, are therefore added in order to give a complete and unbroken record for each corresponding entire season of navigation, the rule being that each season habitually opens in April and closes in December of the same calendar year.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS, ON COMMERCE PASSING ST. MARYS FALLS CANAL, MICHIGAN AND ONTARIO, DURING CALENDAR YEAR 1897.

[Printed in House Doc. No. 329, Fifty-fifth Congress, second session.]

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., February 17, 1898.

GENERAL: I have the honor to transmit herewith statement of freight and passenger traffic to and from Lake Superior, via the St Marys River, during the calendar year 1897, as compiled from reports made by vessel masters when passing through the American and Canadian locks at Sault Ste. Marie, Michigan and Ontario. They show a total freight traffic of 18,982,755 net tons, an increase of nearly two and three-quarter millions, or about 17 per cent over that for 1896; the total passenger traffic was 40,213, an increase of 3,147, or about 8½ per cent. Navigation opened April 21 and closed December 14, 1897, covering therefore, a period of seven months and twenty-four days, during which the average monthly freight traffic was 2,433,686 tons.

The amount of freight passed through the American canal was 14,039,626 tons, an increase over that for the year 1896 of 2,360,60[illegible] tons, or about 20 per cent; the number of passengers was 28,705, as compared with 22,438 for 1896, being an increase of 6,267, or about 2[illegible] per cent.

The amount of freight passed through the Canadian canal was 4,943,129 tons, which was an increase over that for 1896 of 383,092 tons or about 8.4 per cent; the number of passengers was 11,508, as compared with 14,628 for 1896, being a decrease of 3,120, or about 21 per cent.

The American canal passed 74 per cent of the total amount of freight and 71 per cent of the total number of passengers; the Canadian canal 26 per cent and 29 per cent, respectively.

The total number of vessels through both canals was 17,171, against 18,615 for the year 1896, being a decrease of 1,444, or about per cent; the total number of lockages was 8,571, which was 895, or about 9 per cent, less than during 1896. This decreased number of vessel passages and lockages, coupled with the large increase in freight tonnage, is a clear indication of the rapid growth in size of vessels and cargoes that is resulting from the greater navigable depth afforded by the improved channel that has been made by the United States through the St. Marys River, the season of 1897 being the first during which this channel was at all points available for commerce.

Our canal was closed to navigation in 1897 four days earlier than would have been necessary on account of natural causes, in order to

permit us to make preparation for some very important work that was proposed to be done in the interval before navigation was likely to open next spring. This course was made permissible only through the extreme courtesy of Mr. J. C. Boyd, superintendent of the Canadian canal, and its other officials, who gave us the assurance that their lock would be kept open for passing all vessels until final traffic should become impossible on account of ice, though it was then fully known that such extended service would accommodate none other than American craft. The result was that the Canadian canal continued in operation until December 14, thereby prolonging navigation to a later date than in any previous year, and I desire in this report to record my profound appreciation of the benefits accruing to our commerce and the work related to it through this friendly act of our neighbors. It is a natural sequence of other courtesies extended to us, especially as respects the daily transmission of all their records of traffic, formulated in the same shape as those previously adopted for use on our own canal, and therefore so easily incorporated in our own records.

The growth of commerce through the river since the first United States lock at the falls was opened in 1881 is indicated by the following résumé of previous reports:

Year.	Tons.	Year.	Tons.
Total freight during season of—		Total freight during season of—	
1881	1,567,741	1890	9,041,213
1882	2,029,521	1891	8,888,759
1883	2,267,105	1892	11,214,333
1884	2,874,557	1893	10,796,572
1885	3,256,628	1894	13,195,860
1886	4,527,759	1895	15,062,580
1887	5,494,649	1896	16,239,061
1888	6,411,423	1897	18,982,755
1889	7,516,022		

Very respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

Statement of water traffic to and from Lake Superior for the season of 1897, as shown by statistics of the United States and Canadian canals at Sault Ste. Marie, Mich. and Ontario.

Items.	Traffic for 1897.		Total traffic for—		Increase, 1897.		Decrease, 1897.	
	United States canal.	Canadian canal.	Season of 1897.	Season of 1896.	Amount.	Per cent.	Amount.	Per cent.
Vessels a.....number..	12,812	4,359	17,171	18,615	.....	.....	1,444	8
Lockages.....do....	5,967	2,604	8,571	9,466	.....	.....	895	9
Tonnage:								
Registered ....net tons..	13,823,836	3,796,097	17,619,933	17,249,418	370,515	2	.....	.....
Freight .....do....	14,039,626	4,943,129	18,982,755	16,239,061	2,743,694	17	.....	.....
Passengers .....number..	28,705	11,508	40,213	37,066	3,147	8	.....	.....
Coal:								
Hard .....net tons..	435,994	100,205	536,199	397,210	138,989	35	.....	.....
Soft .....do....	2,119,502	383,471	2,502,973	2,626,130	.....	.....	123,157	5
Flour.....barrels..	7,814,745	1,106,398	8,921,143	8,882,858	38,285	.4	.....	.....
Wheat.....bushels..	38,006,977	17,917,325	55,924,302	63,256,463	.....	.....	7,332,161	12
Grain, other than wheat, bushels.....	21,714,731	3,174,957	24,889,688	27,448,071	.....	.....	2,558,383	9

a Steamers, 12,029; sails, 4,438; unregistered, 704. Total, 17,171.

Statement of water traffic to and from Lake Superior for the season of 1897, etc —Cont'd.

Items.	Traffic for 1897.		Total traffic for—		Increase, 1897.		Decrease, 1897.	
	United States canal.	Canadian canal.	Season of 1897.	Season of 1896.	Amount.	Per cent.	Amount.	Per cent.
Manufactured and pig iron, net tons	118,161	17,003	135,164	121,872	13,292	11	.....	.....
Salt.....barrels..	269,189	16,260	285,449	237,515	47,934	20	.....	.....
Copper.....net tons..	117,360	4,964	122,324	116,872	5,452	5	.....	.....
Iron ore.....do....	7,048,586	3,585,129	10,633,715	7,909,250	2,724,465	34	.....	.....
Lumber.....M feet B. M..	795,441	10,171	805,612	684,986	120,626	18	.....	.....
Silver ore.....net tons..	5	.....	5	240	.....	.....	235	98
Building stone.....do....	6,189	60	6,249	17,731	.....	.....	11,482	65
Unclassified freight *a*..do....	483,854	95,194	579,048	520,851	58,197	11	.....	.....

a The item of unclassified freight includes 2,905 tons of wool.

The United States canal was opened April 21 and closed December 10, 1897; season, 234 days.
The Canadian Sault Canal was opened April 21 and closed December 14, 1897; season, 238 days.
United States canal was open to navigation during the season of 1896, 232 days; season of 1897, 234 days.

After the foregoing report had been prepared the office force at the canal was engaged until the middle of April, 1898, in computing and tabulating all data relating to commerce through the canal that had been recorded during the preceding season of navigation. The results are summarized in the following statements and tables. The net ton of 2,000 pounds is meant whenever that unit of weight is used:

(*1*) *Summary of commercial statistics for St. Marys River for season of 1897.*

Total mile-tons	15,969,393,576
Total freight carried.....tons..	18,982,755
Total valuation placed on freight carried	$218,235,927.77
Average value per ton of freight carried	$11.50
Total amount paid for freight transportation	$13,220,099.84
Average distance freight was carried.....miles..	841.3
Cost per mile per ton.....mill..	.83
Average cost per ton for freight transportation	$0.696
Total number registered vessels using canals	848
Total number of passages by unregistered vessels carrying freight..	377
Time American lock was operated.....days..	234
Time Canadian lock was operated.....do...	238
Total valuation placed on registered vessels	$44,377,100
Total number of passengers transported	40,213
Total freight carried by—	
Registered vessels.....tons..	18,953,993
Unregistered vessels.....do...	28,762

(*2*) *Estimated value of freight through St. Marys Falls Canal, Michigan, and Sault Ste. Marie Canal, Ontario, for the season of 1897.*

Items.	Quantity.	Price per unit.	Valuation.
Coal, anthracite.....net tons..	536,199	$5.50	$2,949,094.50
Coal, bituminous.....do....	2,502,973	2.60	6,507,729.80
Flour.....barrels..	8,921,143	4.50	40,145,143.50
Wheat.....bushels..	55,924,302	.87	48,654,142.74
Grain (other than wheat).....do....	24,889,688	.46	11,449,256.48
Manufactured iron.....net tons..	121,848	50.00	6,092,400.00
Pig iron.....do....	13,316	13.25	176,437.00
Salt.....barrels..	285,449	.75	214,086.75
Copper.....net tons..	122,324	200.00	24,464,800.00
Iron ore.....do....	10,633,715	3.00	31,901,145.00
Lumber.....M feet B. M..	805,612	13.50	10,875,762.00
Silver ore.....net tons..	5	112.00	560.00
Building stone.....do....	6,249	10.00	62,490.00
Unclassified freight.....do....	579,048	60.00	34,742,880.00
Total.....	.....	.....	218,235,927.77

Average value per ton of freight for season of 1896	$12.02
Average value per ton of freight for season of 1897	11.50

The authorities for valuations in the foregoing table are as follows: Coal, quotations in Coal Trade Journal, Duluth and Superior; cereals, daily reports in Duluth and Superior journals, with freight to lower lake ports added; iron ore and pig iron, weekly quotations in Iron Trade Review, Marine Record, and Marine Review; salt, quotations Lake Superior ports. Manufactured iron covers such a wide range that it is impossible to assign a strictly correct average price, but $50 is the conventional average. The value of between 4,000,000 and 5,000,000 feet of the lumber included in last year's shipments was as high as $30, but $13.50 is a fair average of all shipments. The stone shipped to lower lake ports is all red sandstone and that to Lake Superior is limestone; $10 is accepted as a fair average valuation. The valuations for copper, silver, and unclassified freight are taken to be the same as in the previous year.

(3) *Cost of carrying freight transported through Sault Ste. Marie Falls Canal, Michigan, and Sault Ste. Marie Canal, Canada.*

[Mile-tons, season of 1897.]

Items.	Quantity.	Price per unit.	Amount.
Coal.....net tons..	3,039,172	$0.30	$911,751.60
Flour.....barrels..	8,921,143	.10	892,114.30
Wheat.....bushels..	55,924,302	.017	950,713.13
Grain (other than wheat).....do....	24,889,688	.02	497,793.76
Manufactured iron.....net tons..	121,848	1.40	170,587.20
Pig iron.....do....	13,316	1.05	13,981.80
Salt.....barrels..	285,449	.15	42,817.35
Copper.....net tons..	122,324	1.95	238,531.80
Iron ore.....do....	10,633,715	.65	6,911,914.75
Lumber.....M feet B. M..	805,612	1.55	1,248,698.60
Silver ore and bullion.....net tons..	5	2.33	11.65
Building stone.....do....	6,249	1.50	9,373.50
Miscellaneous merchandise.....do....	579,048	2.30	1,331,810.40
Total cost.....	.....	.....	13,220,099.84

NOTE.—In this table "tons" mean "net tons," or tons of 2,000 pounds. The total amount of freight paid, $13,220,099.84, divided by the total mile-tons, 15,969,393,576, gives the cost per mile per ton, 0.83 mill. The average distance freight was carried was 841.3 miles, which is 4.9 more than in 1896.

(4) *Classification of registered vessels and their valuation, registered tonnage, and traffic for season of 1897.*

Class.	American craft.					Canadian craft.				
	No.	Registered tonnage.	Freight tonnage.	Passengers.	Valuation.	No.	Registered tonnage.	Freight tonnage.	Passengers.	Valuation.
Steamers...	484	506,487	12,698,150	22,176	$33,963,100	41	21,377	465,517	17,986	$1,793,100
Sails.....	303	250,651	5,702,610	51	8,412,600	20	10,424	87,716	.....	208,300
Total..	787	757,138	18,400,760	22,227	42,375,700	61	31,801	553,233	17,986	2,001,400

(5) *Freight carried by unregistered craft.*

Class.	Number of passages when carrying freight.	Total freight carried.	Average number of tons per passage when carrying freight.
American.....	185	9,560	51
Canadian.....	192	19,202	100
Total.....	377	28,762	.....

The freight carried by Canadian vessels was 3 per cent of the total for the season.

(6) *Freight rates on articles of commerce through St. Marys River for seasons indicated.*

Year.	Coal (per net ton).	Flour (per barrel).	Wheat (per bushel).	Grain (per bushel).	Corn (per bushel).	Oats (per bushel).	Manufactured iron (per net ton).	Pig iron (per net ton).	Salt (per barrel).	Copper (per net ton).	Iron ore (per net ton).	Lumber (per M feet B. M.).	Silver ore (per net ton).	Building stone (per net ton).	General merchandise (per net ton).
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*			*Cts.*						
1887	90	29	(a)	7	(a)	(a)	$2.35	(b)	18	$2.60	$1.75	$4.00	$3.00	$1.15	$4.00
1888	70	17.5	3.5	(c)	4.33	5	1.80	$1.30	16	2.35	1.28	2.80	1.90	2.05	3.00
1889	47	18	4	3.25	(a)	(a)	2.10	1.45	18	2.25	1.14	2.70	1.90	2.02	3.00
1890	45	13	3	.....	3	2	1.34	1.35	15	2.38	1.10	2.38	2.25	2.00	2.75
1891	43	15	4.1	3.5	(a)	(a)	2.50	1.17	18	2.00	.98	2.70	2.25	2.00	3.58
1892	41	16.5	3.1	3.75	(a)	(a)	2.15	1.25	15	1.40	1.00	2.95	2.25	1.67	3.60
1893	40	17	2.8	2.75	2.5	(a)	2.00	1.30	12	1.75	.80	2.35	2.25	1.36	3.00
1894	40	14	2.5	2.75	2.9	(a)	.90	1.15	12	1.95	.70	1.90	2.25	1.28	2.75
1895	37	14	4.4	4.5	(a)	(a)	1.50	1.05	13	1.66	.82	2.00	2.33	1.20	2.50
1896	32	11	2.5	2.25	(a)	(a)	1.40	1.05	15	1.95	.82	1.80	2.33	1.50	2.30
1897	30	10	1.7	2	(a)	(a)	1.40	1.05	15	1.95	.65	1.55	2.33	1.50	2.30

a Included in grain. *b* Included in manufactured iron. *c* Included in corn and oats.

(7) *Cost of transportation, average length of voyages, and rate per ton per mile for seasons indicated.*

Year.	Total cost of transportation.	Average distance freight was carried.	Cost of transportation per mile-ton.
		Miles.	*Mills.*
1887	$10,075,153.13	811.4	2.3
1888	7,883,077.40	806.4	1.5
1889	8,634,246.63	790.4	1.5
1890	9,472,214.90	797.2	1.3
1891	9,849,022.81	820.4	1.5
1892	12,072,850.88	822.4	1.3
1893	9,957,483.11	831.9	1.1
1894	10,798,310.29	828.1	.9
1895	14,238,758.02	830	1.1
1896	13,511,615.80	836.4	.9
1897	13,220,099.84	841.8	.8

The total passages for the season amounted to 17,171, and 1,454 of these were by 90 crafts under 100 tons register. Their aggregate registered tonnage was 2,599 tons, and their average tonnage 29 tons. The freight carried by these crafts during the season only amounted to 2,181 tons.

From the column of largest cargoes it is ascertained that there were 96 propellers that carried in their largest load 2,000 tons and upward; that these cargoes aggregated 244,061 tons and averaged 2,542 tons; there were 83 propellers that carried in their largest load 3,000 tons and upward, aggregating 274,377 tons and averaging 3,306 tons; 23 propellers that carried in their largest load 4,000 tons and upward, aggregating 103,466 tons and averaging 4,499 tons; 12 propellers that carried in their largest load 5,000 tons and upward, aggregating 67,126 tons and averaging 5,594 tons; and 6 propellers that carried in their largest load 6,000 tons and upward, aggregating 36,428 tons and averaging 6,071 tons.

There were 37 sail vessels that carried 2,000 tons and upward, aggregating 90,597 tons and averaging 2,449 tons; 28 sail vessels that carried 3,000 tons and upward, aggregating 100,616 tons and averaging 3,593 tons; 3 sail vessels that carried 4,000 tons and upward, aggregating 12,572 tons and averaging 4,191 tons; 16 sail vessels that carried 5,000 tons and upwards, aggregating 87,462 tons and averaging 5,466 tons; and 2 sail vessels that carried 6,000 tons and upward, aggregating 12,348 tons and averaging 6,174 tons.

The greatest number of miles run during the season is to the credit of the propeller *Harlem*, of the Western Transit Company, of Buffalo, N. Y., amounting to 49,853 miles.

The greatest amount of freight carried by a single vessel during the season is to the credit of the propeller *Andrew Carnegie*, of the Wilson Transit Company, of Cleveland, Ohio, and amounts to 130,956 net tons. The greatest number of mile-tons for the season is to the credit of the same propeller, and amounted to 114,571,524.

The largest single cargo carried by a propeller during the season is to the credit of the propeller *Empire City*, of the Zenith Transportation Company, of Duluth, Minn., and amounted to 6,171 net tons.

The largest single cargo carried by a sail vessel during the season is to the credit of the tow barge *Amazon*, of the Corrigan Steamship Company, of Cleveland, Ohio, and amounted to 6,244 net tons.

The United States canal was open to navigation during the season 234 days, and the Canadian canal 238 days.

The amount of freight carried to and from Lake Superior during the season of 1897 amounted to 18,982,755 net tons, which is an increase of 2,743,694 net tons, or 11 per cent, in comparison with the season of 1896. Vessels were delayed at the canal during the season 7,396 hours and 20 minutes, or an average of 34 minutes and 38 seconds.

The railway swing bridge across the canal was delayed by boats 2 hours and 13 minutes, and the boats were delayed by the bridge only 5 minutes.

St. Marys Falls Canal is in the collection district of Superior, Mich. The nearest port of entry is Marquette, but Sault Ste. Marie is a subport. Two beacons stand upon the piers at the western end of the canal, and Fort Brady is within a mile.

Money statement.

Expended June 30, 1897		$660,218.45
Outstanding liabilities, June 30, 1897		4,587.84
Total expenditures to June 30, 1897		664,806.29
Expended during fiscal year ending June 30, 1898 (including 20 cents paid by Treasury Department, account Western Union Telegraph Company)	$56,674.16	
Deduct outstanding liabilities pertaining to preceding year	4,587.84	
Total pertaining to fiscal year	52,086.32	
Add outstanding liabilities June 30, 1898	6,804.40	
		58,890.72
Total expenditure to June 30, 1898 (including outstanding liabilities)		723,697.01

Estimate.

Amount (estimated) for fiscal year ending June 30, 1899	$90,000
Balance from allotment for preceding year (estimated)	30,000
Additional allotment required for fiscal year ending June 30, 1899	60,000

Expenditures for operating and care of St. Marys Falls Canal, Michigan.

1882	$31,207.48	1892	$61,389.74
1883	35,509.70	1893	42,412.12
1884	31,212.93	1894	55,213.09
1885	27,242.45	1895	50,908.67
1886	25,400.95	1896	60,763.28
1887	22,138.92	1897	78,104.05
1888	29,898.72	1898	58,890.72
1889	30,749.45		
1890	34,323.85	Total	723,697.01
1891	48,330.89		

Statement of receipts and expenditures for fiscal year ending June 30, 1898.

Receipts:		
Balance at close of fiscal year ending June 30, 1897 (including outstanding liabilities)		$19,189.50
July 16, 1897, allotted		70,000.00
October 2, 1897, recovered and deposited by Alfred P. Lyon, United States district attorney, on account of damage to south leaf of lower lock gate, Poe Lock		9.16
		89,198.66
Expenditures:		
Labor, operating	$31,599.74	
Labor, care, and miscellaneous	3,607.92	
Repairs	11,817.61	
General supplies	3,789.65	
Electric lighting	2,697.82	
Contingencies, including office expenses	5,377.98	
		58,890.72
Balance at close of fiscal year ending June 30, 1898		30,307.94

Detailed statement of expenditures made in connection with operating and care of canals and other works of navigation, applied to St. Marys Falls Canal, Michigan, during the fiscal year 1898, as required by section 7 of the river and harbor act of August 11, 1888.

[Items marked + are parts of vouchers.]

Date.	Voucher.	To whom paid.	For what paid.	Amount.
1897.				
Aug	24	W. F. Kingan	Services	$90.00
	25	Ferguson Hardware Co., Limited	Hardware, etc	37.84
	26	P. M. Church & Co	Packing, etc	4.15
	30	Sundry persons	Pay roll	3,344.75
	31	....do	....do	514.75
	+ 66	Hickler Brothers	Material and labor	349.46
Sept	+ 21	Edison Sault Electric Co	Electric current, etc	304.05
	41	Sundry persons	Pay roll	3,241.00
	42	....do	....do	499.60
	+ 64	Hickler Brothers	Material and labor	234.15
	+ 72	Edison Sault Electric Co	Electric current, etc	292.50
	74	J. P. Haller	Stationery	4.30
	+ 81	Western Union Telegraph Co	Telegrams	3.47
	90	L. Pinsonnault	Services	54.29
	92	E. S. Wheeler	Traveling expenses	23.25
	+106	Wallace, Bell & Co	Subsistence stores	21.96
Oct	10	Justin E. Smith	Rent of storeroom	30.00
	33	Lieut. Col. G. J. Lydecker	Mileage	52.16
	+ 34	Wallace, Bell & Co	Subsistence stores	19.43
	39	Sundry persons	Pay roll	464.50
	40	....do	....do	3,673.67
	51	Board of Public Works	Water rent	2.25
	+ 56	Hickler Brothers	Material and labor	128.50
	63	Edison Sault Electric Co	Electric current	315.47
	65	Geo. Headly	Services	2.67

iled statement of expenditures made in connection with operating and care of canals and other works of navigation, etc.—Continued.

[Items marked + are parts of vouchers.]

ate.	Voucher.	To whom paid.	For what paid.	Amount.
897.				
.....	66	Frank Perry	Coal	$53.50
	+ 78	Soo Hardware Co	Hardware, etc	5.25
	85	Michigan Telephone Co	Rent of telephone	9.00
.....	+ 2	Sundry persons	Pay roll	3.00
	+ 14	Wagner Palace Car Co	Sleeping-car service	2.00
	23	Sundry persons	Pay roll	516.57
	24	.....do	.....do	3,974.56
	40	The Erie and Western Transportation Co.	Freight	24.00
	41	Riverside Cartage Co	Boxing, crating, etc	35.00
	56	Edison Sault Electric Co	Electric current	312.00
	57	Vacuum Oil Co	Oil	565.50
	+ 64	Hickler Brothers	Material and labor	371.96
	+ 67	Tymon Lumber Co	Lumber	155.05
	+ 74	Western Union Telegraph Co	Telegram	.27
n.....	26	Sundry persons	Pay roll	4,056.49
	27	.....do	.....do	424.05
	41	Wood & Thoenen	Floor brush, etc	20.85
	44	Western Union Telegraph Co	Telegrams	.90
	63	Edison Sault Electric Co	Electric current	357.27
	64	B. J. Roll	Key chain, rings, etc	13.47
	71	Ferguson Hardware Co., Limited	Diving dresses, etc	133.19
	+ 74	Soo Hardware Co	Hardware, etc	24.55
	+ 75	Hickler Brothers	Material and labor	37.17
	88	First Lieut. J. F. McIndoe	Mileage	30.96
	92	C. B. Robinson	Material and labor	77.08
	+ 96	H. D. Edwards & Co	Brooms, packing, rope, etc	312.39
	+ 99	Paul H. McKlevey	Coal and wheelbarrow	366.00
1898.				
an.....	1	Sundry persons	Pay roll	906.00
	11	Justin E. Smith	Rent of storeroom	30.00
	14	George Kemp	Coal	260.00
	16	Sundry persons	Pay roll	3,621.83
	17	.....do	.....do	197.47
	28	Ben Trudo	Services	13.33
	35	Board of Public Works	Water rent	13.08
	36	Ferguson Hardware Co., Limited	Pearline, rubber cloth, etc	7.13
	+ 41	Soo Hardware Co	Paint	.48
	45	Edison Sault Electric Co	Electric current, etc	130.04
	47	Tymon Lumber Co	Lumber, flooring, etc	51.79
	+ 49	Western Union Telegraph Co	Telegrams	.68
	+ 58	Hickler Brothers	Material and labor	60.26
	+ 67	Wagner Palace Car Co	Sleeping-car service	2.00
eb.....	17	Sundry persons	Pay roll	1,782.16
	20	Lieut. Col. G. J. Lydecker	Mileage	30.96
	+ 30	Wood & Thoenen	Oil, lantern globes, etc	.39
	+ 31	Soo Hardware Co	Hardware, etc	4.79
	+ 32	Edison Sault Electric Co	Electric current, etc	115.60
	37	First Lieut. J. F. McIndoe	Mileage	30.96
	+ 40	Hickler Brothers	Material and labor	81.93
	+ 48	Ferguson Hardware Co., Limited	Hardware, wood, etc	39.45
ar.....	+ 13	Wagner Palace Car Co	Sleeping-car service	4.00
	17	Sundry persons	Pay roll	1,577.50
	24	Michigan Telephone Co	Rent of telephones	81.00
	26	Wood & Thoenen	Steel sink	3.00
	27	P. C. Keliher	Pearline and matches	3.53
	+ 30	Hickler Brothers	Material and labor	103.72
	+ 38	Ferguson Hardware Co., Limited	Hardware, etc	11.65
	39	Edison Sault Electric Co	Electric current, etc	89.14
	+ 40	Paul H. McKlevey	Coal	115.65
	+ 49	Wagner Palace Car Co	Sleeping-car service	6.00
r.....	9	Justin E. Smith	Rent of storeroom	30.00
	14	First Lieut. J. F. McIndoe	Mileage	30.96
	16	Sundry persons	Pay roll	2,318.36
	+ 27	Joseph Ripley	Services	125.00
	31	Board of Public Works	Water rent	18.50
	+ 35	Tymon Lumber Co	Lumber	10.20
	+ 37	Louis Belanger	Services	10.45
	+ 39	James Strachan	Material and labor	67.20
	+ 40	Hickler Brothers	.....do	758.76
	+ 42	Edison Sault Electric Co	Electric current, etc	95.56
	+ 44	Soo Hardware Co	Hardware, etc	675.81
	+ 45	Pullman Palace Car Co	Sleeping-car service	3.50
	48	Michigan Telephone Co	Telephone rent	9.00
	51	Lieut. Col. G. J. Lydecker	Mileage	30.96
	52	The Reinhold Machine Co	Steel rollers, etc	42.50
	56	W. F. Kingan	Material and labor	138.54
	59	Wood & Thoenen	Hardware, etc	428.00
	64	Buhl, Sons & Co	Butts, latches, etc	20.18

Detailed statement of expenditures made in connection with operating and care of canals and other works of navigation, etc.—Continued.

[Items marked + are parts of vouchers.]

Date.	Voucher.	To whom paid.	For what paid.	Amount.
1898.				
May	1	Wagner Palace Car Co	Sleeping-car service	$2.00
	2	Andrew Jackson	Services	150.00
	+ 7	Joseph Ripley	....do	125.00
	16	Sundry persons	Pay roll	4,130.83
	41	J. B. & R. C. Sweatt	Lumber	33.53
	42	Paul H. McElevey	Coal	52.00
	+ 43	Soo Hardware Co	Oil, brooms, etc	1.00
	+ 44	James Strachan	Bolts, and labor on same	28.55
	+ 45	Edison Sault Electric Co	Electric current, etc	150.83
	+ 46	Ferguson Hardware Co., Limited	White lead, hardware, etc	627.45
	+ 47	Hickler Bros	Material and labor	266.12
	51	Baltimore and Ohio R. R. Co	Transportation	14.25
	+ 53	The Richmond & Backus Co	Stationery	46.50
	54	Westinghouse, Church, Kerr & Co	Steam-chest gaskets	6.60
	65	George Kemp	Coal	27.50
	67	Lieut. Col. G. J. Lydecker	Mileage	30.96
June	+ 22	Joseph Ripley	Services	125.00
	34	Sundry persons	Pay roll	5,477.65
	+ 68	Soo Hardware Co	Hardware, etc	26.21
	+ 69	Ferguson Hardware Co., Limited	....do	24.13
	70	Edison Sault Electric Co	Electric current, etc	300.48
	71	John McNaughton	Taking depositions	7.50
	72	Wood & Thoenen	Towels, pearline, etc	6.39
	73	F. W. Roach & Co	Rain coats and hats	14.70
	74	Paul H. McElevey	Coal	102.80
	+ 81	Wagner Palace Car Co	Sleeping-car service	6.00
	+108	Hickler Bros	Material and labor	432.14
	+111	Lieut. Col. G. J. Lydecker	Mileage	26.20
	118	E. R. Spence	Wrenches	6.80
	122	The Erie and Western Transportation Co.	Freight charges	.30
July	+ 2	John O. Campbell	Cartage	.25
	+ 3	Wagner Palace Car Co	Sleeping-car service	4.00
	4	Justin E. Smith	Rent of storeroom	30.00
	6	Chas. L. Roehm & Sons	Record book	10.00
	+ 13	Joseph Ripley	Services	125.00
	25	Harvey C. Beeson	Marine Directory, 1898	5.00
	27	Sundry persons	Pay roll	5,904.72
	35	Michigan Telephone Co	Telephone and office rent	151.33
	66	Board of Public Works	Water rent	18.50
	67	F. L. Rhoades	Services	7.50
	68	Wood & Thoenen	Emery paper, etc	1.88
	74	Edison Sault Electric Co	Electric current, etc	344.04
	+ 75	Hickler Bros	Material and labor	146.84
	+ 76	H. D. Edwards & Co	Ship chandlery, etc	51.84
	+ 96	Pullman Palace Car Co	Sleeping-car service	3.50
				58,890.53
		Paid by Treasury Department, account Western Union Telegraph Co		.20
		Total expended		58,890.73

L L 4.

IMPROVEMENT OF HAY LAKE CHANNEL, ST. MARYS RIVER, MICHIGAN.

This improvement has been in progress since 1883, the object being to make a deep-water channel for commerce through the St. Marys River by a route that can be navigated at night, and that is 11 miles shorter than the one formerly followed. The original estimate was for a channel 17 feet deep and 300 feet wide, but the project has, by subsequent modifications, grown to call for a navigable depth of 20 feet and such width of channel as is essential for safe navigation. The route was opened to navigation June 7, 1894. Work has continued since then to date, with the object of widening the channels to make navigation safer, and deepening a section of the Middle Neebish Cut

where bottom grade was originally made about 2 feet higher than the grade subsequently adopted for other parts of the improvement. Progress on the work to June 30, 1896, is summarized in the Report of the Chief of Engineers for 1896, pages 2877–2878, and from that time to June 30, 1897, in the Report for that year, pages 3006–3008.

Operations during the last fiscal year consisted in dredging for the purpose of widening or deepening the channels at different points, as follows: (1) At turn from Little Mud Lake into the Middle Neebish, and thence to foot of the Middle Neebish Dike. This work was commenced July 23, 1896, and completed August 23, 1897, the total excavation being 116,894 cubic yards, bank measurement, and resulted in increasing the general width of the channel from 300 feet to 800 feet or more, and making the sharp turn at the junction with the Little Mud Lake channel a much safer one. (2) In Middle Neebish, opposite dike. Deepening about 3,000 feet in length. Work commenced September 15, 1897, and is still in progress, the amount excavated to June 30, 1897, being 30,627 cubic yards, scow measurement, all rock. This was the first section of the Hay Lake channel on which any work was done, but after its completion it was found that a lower bottom grade should be adopted for future operations, and the object of the work now in progress is to deepen this initial section to that grade. (3) At angle, foot of Hay Lake, the channel was redredged in order to remove obstructions that had found their way into it since its original completion in 1894; work was commenced June 28 and completed November 2, 1897, the total amount of material removed being 59,878 cubic yards, scow measurement. (4) Off Six-Mile Point, Hay Lake, the channel was widened to an extent gradually increasing from 80 to 500 feet through a distance of 10,000 feet; work was commenced April 26, 1896, and completed July 24, 1897, the total excavation being 560,140 cubic yards. (5) At upper entrance to Hay Lake Channel a small 18-foot shoal was removed and the channel was widened 80 feet for a distance of 600 feet; the work was done between October 11 and 27, 1897, the total excavation being 1,986 cubic yards, scow measurement. (6) St. Marys River, approach to upper entrance to Hay Lake Channel, removing bowlders by diver; work was commenced August 10 and finished November 4, 1897, during which time 1,493 cubic yards, aggregating 2,000 tons in weight, were removed, thereby clearing an area of 125,000 square yards of all obstructions found by the sweeping raft with a depth of less than 21 feet over them.

Extensive surveys were also made during the year, as required for the preparation of estimates, for showing the condition of the improved channels or for projecting other work; and extended examinations were made with the sweeping raft with the bars so adjusted as to detect the existence of any obstructions to navigation in the areas examined.

Details of the operations above referred to are more fully given in the following report by Mr. Benno Rohnert, assistant engineer, in immediate charge:

Item C.—Shoal off Six-Mile Point and widening channel 0 to 800 feet for a distance of 10,000 feet. Contract dated September 19, 1895; W. A. McGillis & Co., of Chicago, Ill., contractors. Rates, 10½ cents per cubic yard, bank measure, to 20 and 21 foot grades, and half rates for first foot below specified grades. Material, sand and clay. Contractors began work on section April 26, 1896.

The dredge *Elevator* worked 38 hours, lost by breakages and delays 214 hours, and excavated 1,465 cubic yards, scow measure. The raft bars were swung over this section in July, showing that the few spots remaining above grade were removed.

This section was finished July 24, 1897. The computations for the final estimate, which were made in duplicate, were finished and submitted September 1. The computed bank measure of material excavated from above the required grades is 360,500.1 cubic yards; for the first foot below the required grades, 100,138.5; below the 21 and 22 foot grades and outside of the side slopes, 99,502.3, making a total of 560,140.9 cubic yards. Total cost for excavation, $42,083.36. This improvement was opened to navigation July 27, on which date the black spar buoys were placed in their new positions.

Item G.—Widening at angle, head of Little Mud Lake, and widening channel from angle to lower end of Middle Neebish Dike, 300 feet wide by 9,600 feet long. Contract dated June 30, 1896; Hingston & Woods, Buffalo, N. Y., contractors. Rates, 34½ cents per cubic yard, bank measure, to 21-foot grade; half rates between 21 and 22 feet. Material, clay, sand, and bowlders. Contractors began work on section July 23, 1896.

Dredging was continued during July and August with one machine, which worked 401½ hours, was delayed 150½ hours, and excavated 46,224 cubic yards, scow measure. This section was finished on August 23, and in such a thorough manner that only one examination with raft and suspended bars was necessary. The duplicate computations for the final estimate showed the bank measure of material removed from above the 21-foot grade to be 47,984.8 cubic yards; between 21-foot and 22-foot grades, 23,170.7; and below the 22-foot grade and outside of side slopes, 45,739.0, making a total of 116,894.5 cubic yards. Additional width of channel was properly marked and used by vessels August 25.

Hire of dredge.—Agreement dated May 7, 1897. H. W. Hubbell & Co.'s dredge No. 3, at the rate of $12.25 per working hour.

The deepening of the channel at the angle foot of Hay Lake, which was begun during the year ending June 30, 1897, was finished November 2. The number of hours of dredging was 796$\frac{15}{60}$ and delays 120$\frac{45}{60}$. The scow measure of sand, clay, gravel, and bowlders was 58,366 cubic yards. The total amount of material removed from the angle was 59,878 cubic yards, at a total cost of $10,072.15, or approximately 16.8 cents per yard.

The time from the 11th to 27th of October was spent in taking four cuts of 20 feet width and 600 feet length on the east side of Hay Lake Channel and abreast of the light-house at its upper entrance, and in removing a shoal about 100 feet square and close to the intersection of the Bayfield Range and center line of Section VI, Hay Lake Channel. At the first-mentioned point there was a ridge of bowlders, clay, and sand; at the second, the same, with bowlders embedded in hard pan. The depth of water was 18 feet. On account of the currents taking two directions at this angle, vessels when bound down would sag over these shoal spots in making the turn. The dredge worked 156$\frac{30}{60}$ hours, was delayed 21$\frac{30}{60}$ hours, and removed 1,986 cubic yards, scow measure, of material, at a total cost of $1,923.05, or 96.8 cents per cubic yard.

Hire of steam derrick scow and diver's outfit.—Agreement dated July 30, 1897; Hickler Brothers' plant. Rate, $4 per working hour.

Operations were begun August 10 and finished November 4. Between these dates the plant was removing bowlders from angle at the upper entrance to Hay Lake Channel, so as to increase the depth of water to 21 feet below the established plane of mean water surface. This was accomplished by 636$\frac{30}{60}$ hours of work and the use of 115 pounds of 60 per cent dynamite. The delays due to breakages, stormy weather, etc., amounted to 89$\frac{15}{60}$ hours. There were removed 1,493 cubic yards of bowlders, some of which were used in reinforcing the dikes cutting off the side streams leading from the main channel. The cost of the work is $2,545.33 for actual hours worked and $18.40 for dynamite, making a total of $2,563.73. The cost per cubic yard, scow measure, was $1.717, and per ton $1.28½. One hundred and twenty-five thousand square yards were swept over.

Item D.—Deepening Middle Neebish Channel 3 feet between cross sections 500 and 760, 300 feet by 2,600 feet. Contract dated September 13, 1897; Hickler Brothers, of Sault Ste. Marie, Mich., contractors. Rates, $2.14 per cubic yard, bank measure, to 21-foot grade, and half-rates between 21 and 23-foot grades. Material, stone, bowlders, and sandstone rock in situ.

Work was begun with dredge No. 8 on September 15, and No. 5 on October 7, stopped for the winter season November 3, and resumed with dredge No. 8 May 18. Time worked, 1,079½ hours; delayed, 155½ hours. Scow measure of excavation, 30,620 cubic yards. The drill, which began operations on May 9, worked 1,033½ hours, was delayed 103¾ hours, and used 35,964 pounds of 50 per cent dynamite in blasting. The number of holes drilled was 6,826 and the total depth 35,037 feet, averaging 5$\frac{1}{8}$ feet to the hole. The holes were drilled 5 feet apart on the cross-sections and 5 to 7 feet apart on the longitudinal sections, depending on the depth of bank to be removed.

Surveys, etc.—During July 3,000 soundings were taken for the final estimate of

Item C; in August, 4,500 for that of Item G, and 4,000 of original bottom for widening Middle Neebish Channel; in November, 1,400 for season's estimate of Item D, Middle Neebish Channel; and during March, 14,830, covering recent operations at Waldo Shoal, Nine-Mile Point Shoal, angle foot of Hay Lake, and Division B, Section IV, Hay Lake Channel, and making a total of 27,730 soundings. For this purpose, and for the guidance of the contractors, 216 section stakes and 6 gauge stakes were driven, and 50 marker buoys and 6 gauge boards placed. All soundings were reduced and mapped on tracing linen or platted on cross-section sheets as occasion demanded. Azimuths from 2 triangulation stations to 22 stakes were computed.

Sweeping with raft.—Waldo Shoal, which had been removed, was swept with raft in July and shown to have a depth of 23½ feet, referred to the established plane of mean water surface. The investigation of the bottom of Hay Lake as to shoal spots was begun.

General.—On account of running ice in the fall of the year quite a number of section stakes became submerged and were dangerous to small craft; 110 were removed. New tripods were placed over four triangulation stations.

The total amount expended to June 30, 1898, was $2,037,440.26, of which $96,421.89 were spent during the past fiscal year.

When the work now in progress of deepening the Middle Neebish section to the grade of the other parts of the Hay Lake Channel is completed, the available depth through this improvement will be 20 feet at mean stage of water, but about 10 miles of the navigable route will still be only 300 feet wide, and this is not a safe width for the character and amount of traffic passing through these channels. Through commerce is increasing so rapidly that measures should be taken without delay for completing the improvement, so that vessels bound in opposite directions will not be required to meet in channels less than 600 feet wide. This may be accomplished by increasing the width of existing channels, but a far better plan, in my judgment, would be to open another route from Hay Lake to Mud Lake via the West Neebish, thereby providing separate channels for up bound and down bound craft.

The unappropriated balance of the original estimate for this improvement will not suffice for completing the work by either course outlined above, but will probably be enough to complete that now in progress on the Middle Neebish and do a small amount of widening at a few other critical points. In the absence of any call by Congress for more extended work the estimate herewith submitted is limited to the amount of that balance, viz, $494,115.

Money statement.

July 1, 1897, balance unexpended		$224,124.10
June 30, 1898, amount expended during fiscal year		96,421.89
July 1, 1898, balance unexpended		127,702.21
July 1, 1898, outstanding liabilities	$13,815.51	
July 1, 1898, amount covered by uncompleted contracts	113,005.82	
		126,821.33
July 1, 1898, balance available		880.88

Amount (estimated) required for completion of existing project	494,115.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	494,115.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations for improving Hay Lake Channel, St. Marys River, Michigan.

August 2, 1882	$200,000.00
July 5, 1884	125,000.00
August 5, 1886	150,000.00
August 11, 1888	500,000.00
September 19, 1890	400,000.00
March 3, 1891 (sundry civil act)	300,000.00
August 5, 1892 (sundry civil act)	115,000.00
March 3, 1893 (sundry civil act)	225,000.00
August 18, 1894 (sundry civil act)	150,000.00
Total	2,165,000.00
Receipts from sales of fuel to officers, between March, 1883, and March, 1887	124.90
Repayment of disallowance, voucher 9, November, 1885 (see p. 2245, Report of Chief of Engineers, 1887)	6.75
Repayment of disallowance, part of voucher 8, August, 1894 (see p. 3052, Report Chief of Engineers, 1895)	10.82
Total	142.47

Abstract of proposals for dredging and submarine rock excavation in the St. Marys River, Michigan (Item D), received in response to advertisement, dated August 2, 1897, and opened August 31, 1897.

Name and address of bidder.	Per cubic yard, bank measurement.
Hickler Bros., Sault Ste. Marie, Mich. *a*	$2.14
G. H. Breymann & Bros., Toledo, Ohio	2.25
The L. P. & J. A. Smith Co., Cleveland, Ohio	2.50
Hingston & Woods, Buffalo, N. Y.	2.60
M. Sullivan, Detroit, Mich.	2.75
Carkin, Stickney & Cram, Detroit, Mich	5.25

a Contract entered into September 13, 1897.

Abstract of contracts in force.

Name of contractor.	Date of approval.	Date of beginning.	Date of expiration.
W. A. McGillis & Co. *a*	Oct. 24, 1895	Apr. 27, 1896	July 1, 1897
Hingston & Woods *b*	July 18, 1896	July 23, 1896	July 1, 1897
Hickler Bros	Sept. 30, 1897	Sept. 15, 1897	June 30, 1899

a Completed July 24, 1897. *b* Completed August 18, 1897.

L L 5.

IMPROVEMENT OF CHEBOYGAN HARBOR, MICHIGAN.

The present project of improvement, as modified by the river and harbor act of June 3, 1896, calls for a channel 200 feet wide and 18 feet deep from deep water in the Straits of Mackinaw to the State road bridge over the Cheboygan River. The improvement was commenced in 1871, and work done since then has served to meet the requirements of commerce up to the present time. The channel was redredged, in

part, in 1895. The Report of the Chief of Engineers for 1896 (pp. 2723–2724) summarizes the history of operations to June 30, 1896, and no work has been done since that time.

The expenditure for the last fiscal year, amounting to $255, was applied to engineering and office contingencies. These included an examination of the harbor June 23, 1898, which showed that considerable shoaling had taken place during the year, especially in the upper portion, where quite a number of soundings of 12 feet were found in midchannel, and in several instances 11½ feet only.

Under provisions of the river and harbor act of August 17, 1894, an estimate for increasing the navigable depth to 18 feet was submitted, and the act of June 3, 1896, appropriated $12,000 for this purpose. The total estimated cost of the project was $33,000, and it will not be expedient to enter upon it until the means available will suffice for dredging the entire length of channel to the prescribed depth for a width of at least 125 feet. An additional appropriation of $15,000 is now needed to accomplish this object.

Cheboygan is in the Michigan collection district, and the nearest port of entry is Grand Haven, Mich. The nearest light-house is on the crib at entrance to the harbor.

Original estimated cost of dredging and pier construction, 1871..... $395,000.00
Whole amount expended to June 30, 1898..... 148,254.49

Money statement.

July 1, 1897, balance unexpended	$12,000.51
June 30, 1898, amount expended during fiscal year	255.00
July 1, 1898, balance unexpended	11,745.51
Amount (estimated) required for completion of existing project	21,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	15,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving harbor at Cheboygan, Mich.

March 3, 1871	$10,000	March 3, 1881	$6,000
June 10, 1872	15,000	August 2, 1882	10,000
March 3, 1873	15,000	July 5, 1884	5,000
June 23, 1874	15,000	August 5, 1886	15,000
March 3, 1875	15,000	August 11, 1888	15,000
August 14, 1876	10,000	June 3, 1896	12,000
June 18, 1878	8,000		
March 3, 1879	3,000	Total	160,000
June 14, 1880	6,000		

COMMERCIAL STATISTICS, CHEBOYGAN HARBOR, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1887	1,587	405,921	1893	1,240	308,129
1888 a			1894	1,350	379,345
1889	1,496	453,456	1895	1,211	378,291
1890 a			1896	1,233	379,069
1891	1,384	367,550	1897	1,216	386,559
1892	1,384	345,174			

a Not stated.

Receipts and shipments by vessel.

[Compiled from statement furnished by Mr. C. S. Marquette, deputy collector of customs, Cheboygan, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Coal	4,700	Farm products	1,100
Flour	1,890	Flour	500
Fruit, miscellaneous	2,100	Grain	688
Grain	6,380	Logs	15,000
Iron and ore	3,750	Lumber	141,185
Lime and cement	1,260	Slabs, telegraph poles, etc	26,128
Logs	89,884	Tan bark	2,785
Lumber	1,738	Unclassified freight	5,691
Machinery	3,750		
Unclassified freight	31,803		
Total	147,255	Total	193,077

L L 6.

IMPROVEMENT OF ALPENA HARBOR (THUNDER BAY RIVER), MICHIGAN.

This harbor is the result of improvements made in the lower reach of Thunder Bay River and the approach to it through shoal water in Thunder Bay. The first improvement was made by local enterprise, work by the Government having been commenced in 1876. The Report of the Chief of Engineers for 1896 (pp. 2725–2726) summarizes the history of operations to June 30, 1896, and no work has been done at the harbor since that time.

The expenditure for the last fiscal year, amounting to $255, was applied to engineering and office contingencies. These included an examination of the harbor in the summer of 1897, when the available channel depth was found to be 12½ feet, a reduction of 3½ feet since the harbor was last dredged in 1893.

Funds on hand will suffice to redredge the channel to the depth of 16 feet, called for by the present approved project, and therefore no additional estimate is now submitted.

Alpena is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. The nearest light-house is at the entrance to the harbor.

Original estimate of cost, 1876, 1881, and 1889 (aggregate)	$55,851.48
Whole amount expended to June 30, 1898	41,952.28

Money statement.

July 1, 1897, balance unexpended	$9,802.72
June 30, 1898, amount expended during fiscal year	255.00
July 1, 1898, balance unexpended	9,547.72

Appropriations for improving harbor at Alpena (Thunder Bay River), Mich.

Thunder Bay Harbor, Michigan:	
August 14, 1876	$4,500
August 2, 1882	15,000
September 19, 1890	5,500
Thunder Bay River, Michigan:	
September 19, 1890	10,000
July 13, 1892	10,000
Alpena Harbor, Michigan:	
August 18, 1894	4,000
June 3, 1896	2,500
Total	51,500

COMMERCIAL STATISTICS OF ALPENA HARBOR (THUNDER BAY RIVER), MICHIGAN, FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.
1893	940	247,278
1894	1,033	303,681
1895	1,249	325,899
1896	1,040	272,921
1897	1,245	353,982

Receipts and shipments by vessel.

[Compiled from statement furnished by Mr. George D. Bradford, deputy collector of customs, Alpena, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Coal	10,311	Cedar posts, telegraph poles, etc	18,149
Logs	45,375	Railroad ties	68,011
Lumber	5,069	Lumber	190,875
Stone	6,250	Tan bark	3,125
Oil	991	Pulp wood	4,687
Unclassified freight	10,382	Unclassified freight	8,314
Total	78,378	Total	293,161

L L 7.

IMPROVEMENT OF SAGINAW RIVER, MICHIGAN.

The present project of improvement aims for a channel 200 feet wide and 14 feet deep from Saginaw Bay to the upper limits of Bay City, and from there a channel of the same width 12 feet deep. The Report of the Chief of Engineers for 1896 (pp. 2727–2728) summarizes the history of operations up to June 30, 1896, and no work has been done since that time, except dredging under a contract then in force; this work was duly completed July 14, 1896, as stated in the last Annual Report (p. 3012).

The expenditure for the last fiscal year, amounting to $697.62, was applied to general office and engineering contingencies, which included the preparation of certain reports called for by the river and harbor act of June 3, 1896, viz:

Estimates of cost of improvement of the Saginaw River from its head to a point in Saginaw Bay, with a view of securing a channel 200 feet wide and an increase in depth to 14 feet from the head of the river to the Third Street Bridge, so called, in Bay City, thence of the same width to Saginaw Bay, with a view to securing an increase of the depth of the channel to 16 feet; also, to submit plans and estimates for improving the west channel of the Saginaw River between the Middle Ground and West Bay City, with a view to securing a depth of said channel to 14 feet; also, to improve the Shiawassee River from the Saginaw River to the Bad River, Bad River to the village of Saint Charles, and the Flint River from the Shiawassee as far as practicable, to such an extent as will afford a reliable navigation for light-draft boats between Saginaw River and the village of Saint Charles, and on the Flint River as far as practicable.

Report was submitted November 22, 1897, and is printed as House Doc. No. 135, Fifty-fourth Congress, second session. It is also submitted herewith as Appendix L L 20.

An examination was made in April, 1898, to ascertain the condition of the channel between Saginaw and deep water in Saginaw Bay, and

it was found that the available depth at many places between Saginaw and Bay City had become reduced to 10 feet, the least depth found in the channel below Bay City being 13 feet. A large amount of dredging is therefore necessary to regain the depths required for commerce on this stream, and called for by the present approved project of improvement; in order to do this, so as to give the redredged channel a minimum width of 100 feet, will require an appropriation of at least $50,000 for the year 1900.

The river is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. There is a light-house at the mouth of the river.

Estimated cost of successive projects, 1867 to 1882	$289,795.00
Estimated cost of project of 1882	446,000.00
Total	735,795.00
Carried to surplus fund	1,000.00
Whole amount expended to June 30, 1898	709,814.89

Money statement.

July 1, 1897, balance unexpended	$38,632.73
June 30, 1898, amount expended during fiscal year	697.62
July 1, 1898, balance unexpended	37,935.11
July 1, 1898, outstanding liabilities	10.00
July 1, 1898, balance available	37,925.11
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1900. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	50,000.00

Appropriations for improving Saginaw River, Michigan.

June 23, 1866	$67,500	July 5, 1884	$50,000
March 2, 1867	28,000	August 5, 1886	33,750
July 25, 1868 (allotment)	9,000	August 11, 1888	65,000
July 11, 1870	1,500	September 19, 1890	75,000
June 23, 1874	15,000	July 13, 1892	100,000
March 3, 1875	30,000	August 18, 1894	40,000
August 14, 1876	11,000	June 3, 1896	40,000
June 18, 1878	25,000	Total	748,750
March 3, 1879	8,000	Carried to surplus fund	1,000
June 14, 1880	15,000	Balance	747,750
March 3, 1881	10,000		
August 2, 1882	125,000		

COMMERCIAL STATISTICS, SAGINAW RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.
1893	1,290	393,487
1894	226	72,707
1895	226	73,689
1896	189	48,752
1897	1,094	330,031

Vessels trading to port.

Description.	Number.	Tonnage.
Steamers	122	37,281
Steam barges	203	51,480
Barges	240	83,575
Schooners	54	24,465
Total	619	196,801

Receipts and shipments by vessel.

[Compiled from statements furnished by Deputy Collectors of Customs C. M. Stewart, of Saginaw, East Side, and D. C. Brawn, of Bay City, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick	17,500	Coal	124,000
Cedar posts, telegraph poles, etc.	2,877	Flour	4,000
Coal	54,741	Grain	1,100
Fruit	3,150	Lath	6,120
Grain	278,856	Logs	11,677
Gravel	162,500	Lumber	133,690
Logs	382,852	Machinery	2,200
Lumber	67,498	Salt	59,285
Merchandise, general	6,449	Unclassified freight	12,788
Stone	16,537		
Tan bark	3,000		
Total	995,960	Total	354,960

L L 8.

IMPROVEMENT OF SEBEWAING RIVER, MICHIGAN.

The facts relating to the improvement of this river, past and prospective, are recited in the last Annual Report, as follows:

The first improvement at this place was made in 1875, when a narrow channel 6 feet deep was dredged from the 6-foot curve in Saginaw Bay to the mouth of the river, and some dredging was also done within the river itself, by which it was straightened and deepened to 6 feet. The total cost of this work was $8,000. The river and harbor act of March 3, 1879, provided for a resurvey of "Sebewaing Harbor," and that of June 14, 1880, appropriated $7,000 for deepening the channel to 7 feet. As recommended in the report on the survey dated April 21, 1880, the money was applied accordingly in 1880–81, and resulted in deepening by about 1 foot the previously dredged channels. Examinations or surveys were again made under the acts of August 2, 1882, September 19, 1890, July 13, 1892, and August 17, 1894.

In accordance with the requirements of the last-named act the following plan of improvement and estimate of cost were prepared and submitted to Congress:

Plan of improvement.—To dredge the entrance channel to a width of 100 feet and depth of 8 feet below the datum plane of the survey of 1895. At the present stage of water in the lake this would give a navigable depth of barely 5½ feet. The length of dredged channel would be about 15,000 feet, and the amount to be excavated is estimated to be 111,267 cubic yards, scow measurement.

Estimate of cost.—The material to be dredged is compact—a mixture of sand and gravel in some parts, hardpan and bowlders in others. The cost of its removal may be averaged at 30 cents per cubic yard, which would make the total cost of the proposed improvement, in round numbers, $37,000, estimated as follows:

Dredging 111,267 cubic yards, at 30 cents	$33,380.10
Add 10 per cent for contingencies	3,338.01
Total	36,718.11

The act of June 3, 1896, appropriated $5,000 for work in accordance with the foregoing plan. It being quite apparent that no useful results could be obtained by the expenditure of so small a sum, work on the project has not yet been commenced.

If the improvement is made it should be started with at least $15,000 available for expenditure. With that amount it would be possible to make a narrow channel from the 8-foot curve in Saginaw Bay to the mouth of the river, the distance being nearly 3 miles.

An expenditure of $15,000 would probably suffice to make a channel 40 feet wide, but such a channel would be of little value or durability. But from the nature of the proposed improvement and the exposure to which the plant engaged on the work must be subjected until most of it is accomplished, it would be a much better policy to appropriate the entire estimated cost before any work whatever is commenced. In no other way can any improvement commensurate with the cost of operations be effected.

The river is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. There is a light-house at the mouth of Saginaw River.

Money statement.

July 1, 1897, balance unexpended	$5,000.00
July 1, 1898, balance unexpended	5,000.00
Amount (estimated) required for completion of existing project	32,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	32,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867, and of sundry civil act of June 4, 1897.	

Appropriations for improving Sebewaing River, Michigan.

March 3, 1875 (river and harbor)	$8,000
June 14, 1880	7,000
June 3, 1896	5,000
Total	20,000

COMMERCIAL STATISTICS, SEBEWAING RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Receipts and shipments.

[Compiled from statement furnished by Messrs. John C. Liken & Co., Sebewaing, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Building stone	4,688	Brick	6,250
Coal	1,200	Coal	80,000
Lath and shingles	1,413	Grain	12,514
Lumber	3,750	Hay	5,000
Salt	630	Headings	1,250
Wheat	1,800	Lumber	4,500
Unclassified freight	37,000	Produce	973
		Staves	27,500
		Unclassified freight	1,700
Total	50,481	Total	139,987

Twenty-five to 30 per cent of the above is now carried by water, and it is represented that with proper harbor facilities fully this amount or more would be added to lake shipments.

L L 9.

IMPROVEMENT OF HARBOR OF REFUGE AT SANDBEACH, LAKE HURON, MICHIGAN.

This improvement, wholly artificial, was made between 1872 and 1885, and its maintenance is of the most vital importance to all commerce passing through Lake Huron. A condensed history of the work is given in the report of the Chief of Engineers for 1896, pages 2730–2731.

Operations during the last fiscal year were confined to a few minor repairs of piers, the work having been done by day labor under the supervision of the custodian of the harbor.

The total amount expended in improving the harbor, its maintenance, and for the supervision and control of vessels entering for shelter to June 30, 1898, is $1,201,350.29, of which $5,045.43 were spent during the last fiscal year.

The harbor was carefully examined June 20–21, 1898. The timber superstructure of the work is in an advanced stage of decay, and that of the main breakwater is so weakened that it is likely to be destroyed by any severe storm in the near future. Its reconstruction can not safely be postponed much longer, and when this is done it should be rebuilt in masonry. An additional appropriation of $250,000 is required for doing the work properly and economically or at any reasonable rate of progress, and it should be made available for expenditure by or before the year ending June 30, 1900.

The number of vessels that took refuge at the harbor during the past fiscal year was 1,114, with a total tonnage of 408,392.49. The grand total of vessels entering for shelter during the calendar years 1877 to 1897, inclusive, is 25,007, the tonnage of which aggregated 8,336,669. The size of vessels sheltered in 1877 averaged 289 tons, and in 1897 this average had increased to 398 tons.

Sandbeach is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. One light-house and three beacons mark the entrances to the harbor, and there is a life-saving station inside.

Original estimated cost of the work	$1,442,500.00
Amount carried to surplus fund	30,000.00
Whole amount expended to June 30, 1898	1,201,350.29

Money statement.

July 1, 1897, balance unexpended		$109,695.14
September 4, 1897, amount collected on account of damage to piers and deposited to the credit of the appropriation		107.05
		109,802.19
June 30, 1898, amount expended during fiscal year		5,045.43
July 1, 1898, balance unexpended		104,756.76
July 1, 1898, outstanding liabilities		223.47
July 1, 1898, balance available		104,533.29
Amount that can be profitably expended in fiscal year ending June 30, 1900		250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

cubic yards. The work was completed November 30, 1897, and the result was to restore the required 16-foot depth over the general area of the bar and the middle ground.

The total amount expended in this locality to June 30, 1898, was $92,369.46, of which $5,440.73 were expended during the last fiscal year.

Experience shows that the shoal will reform in the near future, and it is important that means be at hand to prevent the navigable depth being so reduced as to seriously affect the extensive navigation that is practiced in this locality. An appropriation of $10,000 for this purpose is recommended as a judicious precautionary measure.

The river is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. The nearest light-house is at Fort Gratiot, distant about 2 miles.

Original estimated cost (1871) of removing middle ground to depth of—	
15 feet	$67,320.00
18 feet	157,520.00
Whole amount expended to June 30, 1898	92,369.46

Money statement.

July 1, 1897, balance unexpended	$7,571.27
June 30, 1898, amount expended during fiscal year	5,440.73
July 1, 1898, balance unexpended	2,130.54
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	10,000.00

Appropriations for improving St. Clair River at mouth of Black River, Michigan.

Mouth of Black River, in St. Clair River, Michigan:		Mouth of Black River, Michigan:	
June 10, 1872	$15,000	August 11, 1888	$10,000
St. Clair River, at mouth of Black River, Michigan:		September 19, 1890	10,000
March 3, 1873	15,000	July 13, 1892	10,000
June 23, 1874	15,000	August 18, 1894	4,000
March 3, 1875	10,000	June 3, 1896	4,000
June 18, 1878	1,500	Total	94,500

CONTRACT IN FORCE.

Contract in force with Edmund Hall for dredging bar at mouth of Black River, Michigan, dated May 13, 1897, approved May 20, 1897. Date of beginning work, June 1, 1897; date of expiration, July 29, 1897.

L L 11.

IMPROVEMENT OF BLACK RIVER AT PORT HURON, MICHIGAN.

This improvement was commenced under the river and harbor act of September 19, 1890, and the present project of improvement contemplates dredging the river channel to a depth of 16 feet from the mouth to the Washington Avenue Bridge, the width varying from 150 feet near the mouth to 50 feet in the narrow sections above. Progress of the work

-Classified table of tonnage, by months, sheltered in the harbor of refuge at Sandbeach, Mich., from July 1, 1897, to June 30, 1898.

nths.	Steam.		Sail.		Tow.		Total.	
	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.
97.								
.....	57	17,700.73	32	2,086.31	22	12,239.56	111	32,026.60
.....	59	19,240.96	46	2,398.73	19	7,392.89	124	29,032.58
ır.....	65	29,329.03	41	2,406.93	39	19,774.05	145	51,510.01
.....	80	38,422.33	34	2,109.07	59	25,889.83	173	66,421.23
ır.....	145	93,178.72	48	4,616.85	88	41,470.38	281	139,265.95
r	28	17,218.43	4	291.34	11	8,747.98	43	26,263.75
98.								
.....	1	212.62	.....	.....	2	577.33	3	789.95
.....	46	20,184.87	17	1,564.64	18	7,352.40	81	29,101.91
.....	35	10,795.38	26	1,438.38	24	8,930.47	85	21,164.23
.....	26	7,479.04	37	2,930.70	5	2,406.54	68	12,816.28
tal	542	253,762.11	285	19,848.95	287	134,781.43	1,114	408,392.49

-Number and tonnage of vessels sheltered in the harbor of refuge, Sandbeach, Mich., 1877 to 1897, inclusive.

Calendar year.	Steam.	Sail.	Tow.	Total.	Total vessels.	Average tonnage.
	Tons.	*Tons.*	*Tons.*	*Tons.*		
.....	63,966	27,699	50,954	142,619	493	289
.....	104,025	39,699	99,282	243,006	781	311
.....	133,080	45,750	100,096	278,926	921	303
.....	158,720	55,630	147,260	361,610	1,317	275
.....	144,645	55,960	127,855	328,460	1,176	279
.....	146,132	26,504	114,067	286,703	1,022	280
.....	177,123	32,713	114,091	323,926	1,139	284
.....	156,518	34,724	122,980	314,222	1,142	275
.....	196,364	29,426	151,607	377,397	1,158	326
.....	196,335	33,790	140,862	370,987	1,304	284
.....	271,327	33,689	153,087	458,103	1,447	317
.....	271,917	39,756	202,191	513,864	1,624	316
.....	289,719	37,922	165,896	493,531	1,512	326
.....	325,852	38,826	169,104	533,782	1,575	339
.....	296,917	27,076	171,067	491,060	1,341	366
.....	362,486	29,465	162,605	554,556	1,441	385
.....	243,451	20,897	113,915	378,263	982	385
.....	321,511	22,961	134,034	478,506	1,150	416
.....	356,532	26,898	167,237	550,668	1,204	451
.....	246,477	24,621	105,988	377,087	1,073	351
.....	304,460	21,151	153,776	479,387	1,205	398
Total.....	4,767,556	705,157	2,867,954	8,336,669	25,087	.....

L L 10.

IMPROVEMENT OF MOUTH OF BLACK RIVER, MICHIGAN.

e bar and middle ground in the St. Clair River at the mouth of the k were dredged to a depth of 15 feet in the years of 1872–1875, and dged to 16 feet in 1889–1892, and an outline of operations to June 96, is contained in the Annual Report of the Chief of Engineers at year, page 2735. From that time to June 30, 1897, nothing was except dredging to the extent of 729 cubic yards, being the commement of operations under a contract entered into May 13, 1897, Edmund Hall, of Detroit, Mich., for redredging the shoal area in locality.

erations during the last fiscal year were under the above-mentioned act, and resulted in the excavation of 45,729 cubic yards during ear, making the total amount removed under this contract 46,458

CONTRACT IN FORCE.

Contract in force with Edmund Hall for dredging Black River, at Port Huron, Mich., dated May 13, 1897; approved May 20, 1897; date of beginning work, May 25, 1897; date of expiration, July 17, 1897; completed September 4, 1897.

COMMERCIAL STATISTICS, BLACK RIVER, MICHIGAN, FOR CALENDER YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.	Calendar year.	Number.	Tonnage.
1889	1,612	578,489	1894	595	68,700
1890	2,225	547,954	1895	587	60,650
1891	2,320	578,430	1896	628	72,950
1892[a]			1897	645	121,748
1893	602	71,415			

[a] Not stated.

Receipts and shipments by vessel.

[Compiled from statement furnished by Mr. O. L. E. Weber, superintendent Michigan Sulphite Fiber Works, Port Huron, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Brick	4,610	Lath	125
Coal	85,198	Propeller (built at shipyard)	1,330
Gravel	1,300		
Logs and lumber	20,629		
Machinery	75		
Pulp wood	24,948		
Salt	150		
Shingles, staves, etc	2,065		
Wood	7,950		
Total	96,925	Total	1,455

Fifty-one vessels, representing a total gross tonnage of 11,300 tons, were quartered in Black River during the winter of 1897–98.

L L 12.

IMPROVEMENT OF PINE RIVER, MICHIGAN.

The project of improvement now in course of execution in this river provides for dredging it from its mouth to Belknap's brickyard, a distance of about 5,800 feet, the channel to be 100 feet wide and 14 feet deep for a distance of 2,500 feet upstream, and thence 75 feet wide with a depth of 12 feet for the remaining 3,300 feet. An outline of the work done to June 30, 1897, is given in the Annual Report of the Chief of Engineers for that year (p. 3024). The estimated cost of completing the work as projected was $10,560, and the amount appropriated therefor to date is $5,000.

No work was in progress during the last fiscal year. The total expenditure to June 30, 1898, was $9,461.95, of which $9 were expended during the last fiscal year.

The improvement has not been examined since operations were suspended, November, 1896, but it is reported that the upper section, 3,300 feet in length, which was dredged for a width of only 30 feet, has shoaled considerably since that time.

An additional appropriation of $5,560, being the balance of the estimated cost, will be required to complete the improvement as projected.

The river is in the collection district of Huron, Mich. The nearest port of entry is Port Huron, Mich. The nearest light-house is at Fort Gratiot, distant about 13 miles.

Money statement.

July 1, 1897, balance unexpended	$547.05
June 30, 1898, amount expended during fiscal year	9.00
July 1, 1897, balance unexpended	538.05
Amount (estimated) required for completion of existing project	5,560.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	5,560.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving Pine River, Michigan.

March 3, 1875	$5,000
June 3, 1896	5,000
Total	10,000

COMMERCIAL STATISTICS, PINE RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Receipts and shipments by vessel.

[Compiled from statement furnished by Messrs. J. R. Whiting & Co., St. Clair, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Limestone	350	Brick	6,250
		Lime	220
Total	350	Total	6,470

Thirteen steamers and barges were laid up in Pine River during the winter of 1897-98.

L L 13.

IMPROVEMENT OF BELLE RIVER, MICHIGAN.

An improvement of this river was made between 1880 and 1885, at a total cost of $14,000, by dredging a channel 50 feet wide and 13 feet deep for a distance of about 6,000 feet from the mouth. The depth gradually decreased until the river and harbor act of June 3, 1896, appropriated $5,000 for redredging the channel to a navigable depth of 15 feet from the mouth to the first bridge above, and from there to the second bridge to a depth of 14 feet. Operations under this project

were commenced June 12, 1897, under contract with Edmund Hall, of Detroit, Mich., dated May 13, 1897, and up to June 30 of that year 14,086 cubic yards had been excavated.

Operations under the above contract were continued until August 1, 1897, when the available funds became so reduced as to cause a suspension of operations. The amount excavated during the fiscal year was 24,949 cubic yards, making the total excavation since the beginning of operations 39,035 cubic yards. The result was to provide a channel 15 feet deep and about 75 feet wide from the mouth of the river for a distance of about 2,400 feet upstream.

The total expenditure to June 30, 1898, was $18,928.10, of which $4,605.38 were spent during the last fiscal year.

The channel has not been examined since operations were suspended in the summer of 1897, but it is reported that considerable shoaling has taken place since then. The completion of the improvement as projected will require an additional appropriation of $10,000.

The river is in the collection district of Huron, Mich., and the nearest port of entry is Port Huron, Mich. The nearest light-house is at St. Clair Flats Canal, distant about 17½ miles.

Money statement.

July 1, 1897, balance unexpended	$4,677.28
June 30, 1898, amount expended during fiscal year	4,605.38
July 1, 1898, balance unexpended	71.90
Amount (estimated) required for completion of existing project	10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving Belle River, Michigan.

March 3, 1881 (ice harbor of refuge)	$7,000
August 2, 1882 (ice harbor of refuge)	5,000
July 5, 1884 (ice harbor of refuge)	2,000
June 3, 1896	5,000
Total	19,000

CONTRACT IN FORCE.

Contract in force with Edmund Hall for dredging Belle River at Marine City, Mich., dated May 13, 1897; approved May 20, 1897. Date of beginning work, June 12, 1897; date of expiration, July 23, 1897; completed July 31, 1897.

COMMERCIAL STATISTICS, BELLE RIVER, MICHIGAN, FOR THE CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.
1897	52	3,093

Receipts by vessel.

[Compiled from statement furnished by Mr. R. B. W. Beattie, deputy collector of customs, Marine City, Mich.]

	Tons.
Coal	950
Logs	7,918
Lumber	2,288
Unclassified freight	240
Total	11,396

Thirty-seven vessels, representing a total gross tonnage of 14,000, were quartered in Belle River during the winter of 1897–98.

L L 14.

IMPROVEMENT OF ST. CLAIR FLATS CANAL, MICHIGAN.

The history of this improvement to June 30, 1896, is outlined in the Report of the Chief of Engineers for that year (pp. 2881–2889), and no work has been done since then.

The total expenditure to June 30, 1898, was $761,750.61, of which $1,527.15 were spent during the last fiscal year. This expenditure was for office and engineering contingencies, which included some local surveys made with a view to preparing plans and estimates for further improvements.

No specific appropriation has been made for this work since 1890, the cost of operations, care, and maintenance being provided by allotments from the permanent indefinite appropriation for operating and care of canals and other works of navigation.

St. Clair Flats Canal is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. Two light-houses stand upon its banks.

Money statement.

July 1, 1897, balance unexpended	$4,586.54
June 30, 1898, amount expended during fiscal year	1,527.15
July 1, 1898, balance unexpended	3,059.39

Appropriations for improving St. Clair Flats Canal, Michigan.

June 23, 1866	$80,000	June 18, 1878	$5,000
March 2, 1867	150,000	March 3, 1879	3,000
July 25, 1868	86,000	June 14, 1880	2,500
April 10, 1869	142,560	August 5, 1886	18,750
July 11, 1870	16,500	August 11, 1888	75,000
March 3, 1871	1,500	September 19, 1890	80,000
June 10, 1872	4,000		
March 3, 1873	100,000	Total	764,810

NOTE.—The appropriations of 1852, $20,000, and 1856, $45,000, are not taken account of, for the reason that they did not enter into the improvement of St. Clair Flats Canal, the first having been expended in building a dredge and the second in dredging the North Channel of the South Pass. From March 3, 1881, the amounts allotted for operating and care of St. Clair Flats Canal are rendered separately.

L L 15.

OPERATING AND CARE OF ST. CLAIR FLATS CANAL, MICHIGAN.

Conforming to the method that has been followed since the canal was opened to navigation in 1871, a custodian was present on the work during the season of navigation to watch the passage of vessels, enforce regulations respecting navigation through the canal and its approaches, and supervise such work as was requisite for ordinary care and repair of the canal dikes. Expenditures on this account during the fiscal year were $2,099.65.

It has been apparent for a few years past that the limited project followed up to the present time should be very much enlarged, and a substitute was therefore recently submitted for the ensuing fiscal year, as follows:

First project.—This is to continue as heretofore, and commit the immediate care and supervision of the canal and the enforcement of canal regulations to a single custodian, limiting repairs to such as become necessary as a result of some accident.

The estimate for this limited project is $5,000, as in years past, viz:

Salary of custodian	$1,500
Usual repairs	2,500
Contingencies, including office expenses	1,000
Total	5,000

The unexpended balance of the last allotment, being in round numbers $500, leaves $4,500 as the additional amount required if this project be adhered to. I do not recommend this course, for reasons indicated below.

Second project.—The project outlined above does not, and can not, provide for (1) an efficient supervision of the canal; (2) a continuous or careful observation of vessels passing through it; (3) the detection of offenses against the regulations governing its use, except in a very few instances and in these it is accidental; or (4) for supplying such testimony as is required to convict persons charged with offenses when they are brought before the court. It is not necessary to refer to experience respecting any but the last of these points to show that the lone costodian is unequal to the above requirements. On that latter point this experience is that the unsupported testimony of the custodian is invariably powerless against a vessel master with his well-drilled crew of witnesses to back him up on the stand. The testimony of at least two witnesses, or its equivalent, is necessary for conviction, and such testimony the Government is generally unable to produce. The effect of the whole system is to weaken and discredit the attempt at governmental regulations. The first project also omits to provide for the extensive general repairs that have now become a matter of almost extreme necessity, and the work, being a conspicuous feature in the line of travel through the lakes, is viewed and criticised by thousands, to the great discredit of the service responsible for its present condition of rank ruin and unsightliness. In view of all these considerations my last project of operations (June 27, 1896) suggested a more extensive one, from which the following is quoted:

> The wooden superstructure of the old dikes has become thoroughly rotten, large sections of it have fallen away, iron bolts project from 1 to 2 feet above what remains, and as a whole it is in an utterly dilapidated and disreputable condition; all old timbers should be removed down to the water surface and the earth back of them graded back to a proper slope. The two dikes aggregate about 15,000 feet in length,

ıd, estimating the proposed repairs at $2 per linear foot, the total cost would be 0,000.

The old pile structures by which the ends of each dike are protected are badly tted above water and broken down in part. They should be cut down to, and built above, the water surface. To do this properly would cost about $5,000. I ıde a careful examination of the whole work on the 22d inst., and believe these neral repairs to be urgently requisite.

A proper enforcement of the canal regulations has become a matter of grave ıportance, because of the vast passing commerce, but this is utterly impossible so ng as there is only a single custodian charged with this duty. There should be 'o watchmen on duty at all times, day and night; one stationed at the upper trance to the canal and the other at the lower one. Such a system would require t watchmen to serve in three watches of reliefs, and, with pay at $60 per month ch, would cost $4,320 annually.

A telephonic system of communication should be established between the upper d lower watch stations. Its cost would probably be about $2,500.

The custodian should be supplied with a small steam launch, costing probably ,000, and operated at an annual expense of about $1,500.

An office building should be erected at a cost of about $5,000.

Such an organization is essential to a satisfactory supervision of traffic through e canal, and it would also enable a careful record of passing commerce to be made, ereby giving accurate statistics of commerce between the upper and lower lakes.

Being now still more fully convinced of the necessity of entering ıon a project substantially as that outlined above, I recommend its loption, and submit the following as the estimated cost, during the 'st year only, for approval:

ıstodian, at $1,200 per year	$1,200
vatchmen, at $60 per month each, for 10 months	3,600
fice building, with quarters for custodian and watchmen	5,000
lephone line	500
eam launch	1,500
ıerating steam launch	1,500
ıeral repairs of dikes and pile protection	27,000
ıpervision, engineering, and office contingencies	5,000
Total	45,300

Making the additional allotment required for this year's project 5,000 in round numbers.

It will be observed that the above estimate is $11,520 less than that ıbmitted in 1896, the probable cost of repairs having been more care- lly computed since that time, and better information obtained respect- ıg other items.

It has been suggested that Congressional action is necessary before ıtering upon this enlarged project, but section 4 of the act of July 5, 884, provides that "The Secretary of War, upon the application of he Chief Engineer in charge of said works, is authorized to draw his 'arrant or requisition upon the Secretary of the Treasury to pay the ctual expenses of operating and keeping said work in repairs," etc. This legislation appears to devolve upon the officer in charge the duty ınd responsibility of indicating what is needed in such cases, and duly ıuthorizes the necessary expenditure. It would therefore seem that further Congressional action is not only unnecessary, but that to await it might not be in full accord with the spirit and object of the law just quoted. The principal item of expenditure in the project now sub- mitted is for extensive general repairs that have become urgently nec- essary as a result of twenty-eight years' wear and tear, during which no expenditure for the purpose now contemplated has been made. Having made these repairs, the annual cost of operating and care will fall to $8,000 or less.

St. Clair Flats Canal is in the collection district of Detroit, Mich. The nearest port of entry is Detroit. Two light-houses stand upon its banks.

Money statement.

Expended to June 30, 1897		$73,895.78
Outstanding liabilities June 30, 1897		175.00
Total expenditures to June 30, 1897		74,070.78
Expended during fiscal year ending June 30, 1898	$2,056.53	
Deduct outstanding liabilities pertaining to preceding year	175.00	
Total pertaining to current fiscal year	1,881.53	
Add outstanding liabilities June 30, 1898	218.12	
		2,099.65
Total expenditure to June 30, 1898 (including outstanding liabilities)		76,170.43

Estimates for year ending June 30, 1899.

If old project be continued	$5,000
If new project be adopted	45,000

Expenditures for operating and care of St. Clair Flats Canal, Michigan.

1882	$8,786.69	1892	$1,888.67
1883	5,668.87	1893	2,675.93
1884	2,532.15	1894	3,592.18
1885	4,906.59	1895	1,993.32
1886	9,539.11	1896	2,501.57
1887	1,819.53	1897	2,162.81
1888	1,510.00	1898	2,099.65
1889	20,315.00		
1890	2,158.16	Total	76,170.43
1891	2,020.20		

Statement of receipts and expenditures for fiscal year ending June 30, 1898.

Receipts:		
Balance at close of fiscal year ending June 30, 1897 (including outstanding liabilities)		$2,660.62
Expenditures:		
Salary of custodian	$1,500.00	
Ordinary repairs	126.75	
Contingencies	472.90	
		2,099.65
Balance at close of fiscal year ending June 30, 1898		560.97

Detailed statement of expenditures made in connection with operating and care of canals and other works of navigation, applied to St. Clair Flats Canal, Michigan, during the fiscal year 1898, as required by section 7 of the river and harbor act of August 11, 1888.

Date.	Voucher.	To whom paid.	For what paid.	Amount.
1897.				
August	17	Sundry persons	Pay roll	$175.00
	32	do	do	35.00
	a 47	Henry Howard estate	Timber	36.43
	56	Jos. Wood & Sons	Screw-bolts and spikes	12.20
September	34	Sundry persons	Pay roll	175.00
October	15	do	do	175.00
	31	J. C. Goss & Co	United States flag	8.50
November	18	Sundry persons	Pay roll	175.00
December	4	do	do	175.00

a Part of voucher.

Detailed statement of expenditures made in connection with operating and care of canals and other works of navigation, etc.—Continued.

Date.	Voucher.	To whom paid.	For what paid.	Amount.
1898.				
January	12	Sundry persons	Pay roll	$165.00
	51	Detroit Citizens Street Railway Co.	Car tickets	10.00
	65	Lucy Smith	Laundering	6.00
	68	H. D. McElroy	Repairing stool, etc	.80
	69	Sunley & Geary	Repairing dating stamp	1.50
February	5	W. H. Mott	Services	125.00
March	6	do	do	125.00
April	7	do	do	125.00
May	3	Sundry persons	Pay roll	175.00
June	7	do	do	175.00
	115	E. W. Sprague	Typewriting paper, etc	11.10
July	18	Sundry persons	Pay roll	186.50
	113	Henry Howard estate	Timber	11.63
	119	McHaney Bros	Pulling piles	20.00
		Total expended		2,099.65

L L 16.

IMPROVEMENT OF CLINTON RIVER, MICHIGAN.

The improvement of this stream, commenced in 1870, has been carried on since then as funds were appropriated, and an outline of the work done to June 30, 1896, is printed in the Report of the Chief of Engineers for that year (pp. 2736–2737).

The object sought by the approved project of improvement is to maintain a channel 8 feet deep from the mouth of the river to the city of Mount Clemens, 8 miles above.

An examination of the stream made in the spring of 1897 having shown that the improved channel had shoaled to such an extent as to afford an available depth of only 4½ to 5 feet in many places, a contract was entered into May 13, 1897, with Edmund Hall, of Detroit, Mich., for redredging the river, and work under the contract was commenced June 10, 1897.

Operations during the last fiscal year were confined to dredging in continuation of the work in progress at its commencement until September 6, 1897. The amount excavated during the year was 25,708 cubic yards, making the total amount dredged under contract 34,363 cubic yards, which resulted in restoring the depth of 8 feet throughout the river to Mount Clemens; but the channel thus provided was a narrow one and is not likely to have any considerable duration. The river has not been examined since operations were suspended in the fall of 1897, and the extent of deterioration, if any, is not now known.

The whole amount expended for the improvement of the river to June 30, 1898, was $67,672.58, of which $7,156.59 were spent during the last fiscal year.

The balance of funds available for further work will probably suffice for doing such dredging as is necessary to maintain the required navigable depth during the year ending June 30, 1900, and therefore no additional estimate for this purpose is now presented.

The river is in the collection district of Detroit, Mich., which is the nearest port of entry. The nearest lighthouse is 6 miles distant, at St. Clair Flats.

Original estimated cost of work, 1885, as amended in 1889	$34,564.00
Whole amount appropriated and expended prior to adoption of present project	25,500.00
Whole amount expended on present project to June 30, 1898	42,172.58

Money statement.

July 1, 1897, balance unexpended	$14,548.01
June 30, 1898, amount expended during fiscal year	7,156.59
July 1, 1898, balance unexpended	7,391.42

Appropriations for improving Clinton River, Michigan.

August 30, 1852	$5,000	September 19, 1890	$10,000
July 11, 1870	5,000	July 13, 1892	8,564
March 3, 1871	1,500	August 18, 1894	5,000
March 3, 1881	8,000	June 3, 1896	10,000
August 2, 1882	6,000		
August 5, 1886	6,000	Total	75,064
August 11, 1888	10,000		

CONTRACT IN FORCE.

Contract in force with Edmund Hall for dredging Clinton River, Michigan, dated May 13, 1897, approved May 20, 1897; date of beginning work, June 10, 1897; date of expiration, August 19, 1897. Completed September 8, 1897.

COMMERCIAL STATISTICS, CLINTON RIVER, MICHIGAN, FOR CALENDAR YEAR ENDING DECEMBER 31, 1897.

Entrances and clearances.

Calendar year.	Number.	Tonnage.
1896	420	25,122
1897	420	(a)

a Not stated.

Vessels trading to port.

Description.	Number.	Tonnage.
Steamers	7	167
Steam barges	3	222
Tow barges	5	196
Schooners	12	677
Scows, etc.	9	234
Total	36	1,496

Receipts by vessel.

[Compiled from statement furnished by Mr. F. R. Eastman, secretary Chamber of Commerce, Mount Clemens, Mich.]

	Tons.
Coal	8,345
Gravel	5,200
Lath, shingles, etc	1,761
Logs	2,750
Lumber	9,252
Salt	84
Stone	1,687
Total	29,077

L L 17.

IMPROVEMENT OF DETROIT RIVER, MICHIGAN.

The shoalest part of the channel in this river before improvement was at the Lime Kiln Crossing, where the depth at the ordinary stages of water was 13 feet, while above and below the crossing the channel was obstructed by numerous shoals, and studded with bowlders having only 15 to 16 feet of water over them in many instances. The work of improvement was commenced in 1874, and operations since then under the several projects adopted had resulted, to June 30, 1897, in making a channel 20 feet deep by 440 feet wide at the crossing, and removing obstructions from the channel above and below to such an extent as to permit the safe passage of vessels drawing 16½ feet and to make the available depth at most places 18 feet or more. The total estimated cost of the original project and its subsequent extensions was $1,554,500. The Reports of the Chief of Engineers for 1896 and 1897, pages 2893–2895 and 3029, respectively, outline the progress of operations up to the beginning of the last fiscal year.

Operations during the last fiscal year were in continuation of a contract entered into June 12, 1897, with Michael Sullivan, of Detroit, Mich., to improve the so-called Ballards Reef Channel by dredging and the removal of bed rock and bowlders. Work was continued until October 2, 1897, when the appropriation became exhausted and the contract was closed. The result of the season's work was to increase the navigable depth from 16½ to 18 feet, and to clear a considerable area of the channel to the full depth of 21 feet. Details of operations are given in the following report prepared by Mr. Charles Y. Dixon, assistant engineer in local charge:

Ballard's Reef.—This work was continued until October 2, 1897, under formal contract with Mr. Michael Sullivan, of Detroit, Mich., dated June 12, 1897. The work consisted in drilling and blasting bed rock and large bowlders and in removing the blasted material, together with all other material found above the prescribed grade (21 feet); the work of removal being done by divers and loaded on derrick scows or by dredging, as circumstances required. The object in view is to clear the channel of all obstructions above a depth of 21 feet and for a width of 600 feet.

The amount of material removed was 10.855.391 tons. This material was removed from the east side of the range line, and also from a bed-rock shoal 150 feet wide and 250 feet long, adjacent to a line 300 feet west of the range line. For the past three seasons vessels have used the west half (300 feet) of the channel, throughout which there was a clear depth of 18 feet, with the exception of the bed-rock shoal here referred to, over which there was a least depth of about 16.5 feet. Much damage was done to vessels by grounding on this shoal, and navigation has been greatly benefited by its removal, which was accomplished to 21 feet depth in September, 1897.

The total expenditure to June 30, 1898, was $793,110.41, of which $52,736.39 were spent during the last fiscal year.

The completion of this improvement so as to obtain a channel with a clear navigable depth of 20 feet and width of 600 to 800 feet according to locality, from the head of Ballards Reef to the mouth of the river, is of the greatest importance to lake commerce. The total amount appropriated for carrying on the work under the several projects since 1874 is $793,000, and this deducted from their total estimated cost ($1,554,500) leaves $761,500 as the estimated amount required for their completion; but it is highly probable that it can be done for less if the appropriations are such as to admit of practically continuous work.

Accurate statistics of the amount of commerce through Detroit River are not obtainable, but it is estimated to have included something over 30,000,000 tons of freight during the calendar year 1897.

Money statement.

July 1, 1897, balance unexpended	$52,735.39
June 30, 1898, amount expended during fiscal year	52,735.39
Amount (estimated) required for completion of existing project	761,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving Detroit River, Michigan.

June 23, 1874	$25,000	August 5, 1886	$37,500
June 18, 1878	100,000	August 11, 1888	130,500
March 3, 1879	50,000	July 13, 1892	30,000
June 14, 1880	50,000	August 18, 1894	30,000
March 3, 1881	50,000	June 3, 1896	30,000
August 2, 1882	60,000		
July 5, 1884	200,000	Total	793,000

Receipts from sales of fuel to officers, between October, 1884, and December, 1886	$108.41
Repayment of disallowance voucher 4, November, 1885 (see p. 2268, Report Chief of Engineers, 1887)	2.00
Total	110.41

CONTRACT IN FORCE.

Contract in force with Michael Sullivan for removal of bowlders, etc., from Ballards Reef Channel, dated June 12, 1897, approved June 29, 1897. Date of beginning work, June 18, 1897; date of expiration, October 18, 1897. Completed October 2, 1897.

L L 18.

IMPROVEMENT OF ROUGE RIVER, MICHIGAN.

Under the provisions of the river and harbor act of August 5, 1886, a survey of this river was made with a view to its improvement, and a project prepared for securing a channel depth of 16 feet, with a width of 240 feet for a distance of 800 feet from the mouth, and thence with a width of 100 feet to the Wabash Railroad bridge, about 2¼ miles farther up; the estimated cost was $31,690.39. At the time of survey this portion of the river had a natural channel from 10 to 17 feet deep, with a general width of about 175 feet. The work of improvement was commenced in 1888 and completed in November, 1892.

No work has been done on the river since 1892, but under the provisions of the river and harbor act of June 3, 1896, the section of river heretofore improved was examined in May, 1897, and survey made for estimating the cost of extending the original improvement about 8,000 feet farther up stream.

The total expenditure for the improvement of this river to June 30, 1898, was $32,188.45, of which $394 were expended during the last fiscal year.

The result of the examination and survey above referred to were submitted in a special report dated November 20, 1897, and printed as

House Doc. No. 138, Fifty-fifth Congress, second session. It is also submitted herewith as Appendix L L 22.

The balance of funds available is sufficient to maintain the improvement heretofore authorized, and for this reason no additional estimate is submitted for that purpose for 1900.

The river is in the collection district of Detroit, Mich., which city is the port of entry. The nearest light-house is about 5 miles distant, at Grassy Island.

Original estimated cost of the work, 1887	$31,690.39
Whole amount expended to June 30, 1898	32,188.45

Money statement.

July 1, 1897, balance unexpended	$9,895.55
June 30, 1898, amount expended during fiscal year	394.00
July 1, 1898, balance unexpended	9,501.55

Appropriations for improving Rouge River, Michigan.

August 11, 1888	$10,000
September 19, 1890	10,000
July 13, 1892	11,690
August 18, 1894	5,000
June 3, 1896	5,000
Total	41,690

Vessels trading to port: 12 steamers, 42 steam barges, 31 tow barges, 42 schooners, and 136 scows, sloops, etc.

Receipts and shipments by vessel.

[Compiled from statement furnished by Mr. W. W. Kelly, secretary Delta Lumber Company, Detroit, Mich.]

Articles received.	Tons.	Articles shipped.	Tons.
Cedar posts, telegraph poles, etc.	8,922	Lumber	3,600
Logs	43,750	Salt	225
Lumber	51,345	Slabs, headings, etc.	561
Pulp wood	11,970	Soda ash	5,000
Total	115,987	Total	9,386

L L 19.

CONSTRUCTION OF TURNING BASIN IN ROUGE RIVER, MICHIGAN.

No work has been done nor expenditure made on account of this proposed improvement, and everything relating to it remains precisely as stated in my last annual report, viz:

The river and harbor act of September 19, 1890, called for an estimate for "locating and constructing basin in said (Rouge) river at a point on the same within 4 miles of its junction with the Detroit River, convenient for the turning and anchoring of vessels." Such estimate was submitted by Col. O. M. Poe, Corps of Engineers, in a report dated December 20, 1890, as follows: Three acres of land for site, at $1,500, $4,500; 74,047 cubic yards excavation, at 15 cents, $11,111.10; total, $15,611.10.

The next river and harbor act, approved July 13, 1892, appropriated $5,000 for acquisition of land and beginning construction, according to the foregoing project. The appropriation has been found too small for purchasing the land needed, and

ordingly no work has yet been done or expenditure made in relation to the pro-
ed improvement.
t is doubtful whether the construction of the proposed basin will be really neces-
y, for private parties have already constructed slips opening into the river (and
ers will undoubtedly follow) that will supply openings opposite which vessels
l in all probability be able to find turning room. If, however, the plan of con-
ucting a turning basin is to be adhered to, work should not be commenced until
the money required to complete it has been appropriated; in this case an addi-
ıal appropriation of $10,500 should be made, as indicated in the estimate submit-
below. But it is suggested that the scheme be abandoned, for the present at
st, and the money already appropriated be made available for general dredging
:he Rouge River.

I know of no better way of disposing of this matter than to follow
› suggestion contained in the closing paragraph of the foregoing
otation.

propriation for construction of turning basin in Rouge River, Michi-
an, July 13, 1892 ..... $5,000.00
ginal estimated cost of the work, 1890 ..... 15,611.10

Money statement.

y 1, 1897, balance unexpended $5,000.00
y 1, 1898, balance unexpended 5,000.00

mount (estimated) required for completion of existing project 10,611.10
mount that can be profitably expended in fiscal year ending June 30, 1900 15,500.00
ubmitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

L L 20.

RVEY OF SAGINAW, SHIAWASSEE, BAD, AND FLINT RIVERS, MICHIGAN.

[Printed in House Doc. No. 135, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 6, 1897.

it the accompanying copy of report of

Saginaw River.—This river is now being improved by the United States under a project, adopted in 1882, which provides for making a channel 200 feet wide, 14 feet deep from Saginaw Bay to Bay City, and 12 feet deep thence to Saginaw.

The improvement suggested by the act contemplates channels 2 feet deeper than those provided for in existing project and an extension of operations 2½ miles farther upstream than any work thus far done, estimated by Lieutenant-Colonel Lydecker to cost, for the main channel, $452,925, and for the west channel, between Middle Ground and West Bay City, $29,700; in all, $482,625. Lieutenant-Colonel Lydecker adds, however, that the improvement could not be completed on this estimate except with large appropriations, admitting of continuous work, and that subsequent maintenance will cost at least $15,000 annually.

Shiawassee and Bad rivers.—The projects proposed for these streams provide for dredging a channel 50 feet wide and 6 feet deep in Shiawassee River from Saginaw River to Bad River, and up Bad River to the village of St. Charles, estimated to cost $21,000, but Lieutenant-Colonel Lydecker states that a temporary improvement that would meet the immediate requirements of navigation within the proposed limits could probably be made with an expenditure of $5,000, resulting in a navigable depth of about 5 feet.

Flint River.—The improvement of this stream "as far as practicable" from its mouth, a distance of about 4 miles, by dredging a channel 50 feet wide and 6 feet deep will cost, as estimated by Lieutenant-Colonel Lydecker, $15,000.

Section 9 of the act of June 3, 1896, also provides for a survey of Saginaw River, and the report and estimate above given are intended to comply with the requirements of this section as well as those of section 1.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., November 22, 1897.

GENERAL: In accordance with instructions contained in Department letter of July 24, 1896, I have to submit report on the following requirements of the river and harbor act of June 3, 1896:

The Secretary of War is hereby directed to cause surveys to be made and estimates of the cost of improvement of the Saginaw River from its head to a point in Saginaw Bay, with a view of securing a channel two hundred feet wide and an increase in depth to fourteen feet from the head of the river to the Third Street Bridge, so called, in Bay City, thence of the same width to Saginaw Bay with a view to securing an increase of the depth of the channel to sixteen feet; also to submit plans and estimates for improving the west channel of the Saginaw River between the Middle Ground and West Bay City with a view to securing a depth of said channel to fourteen feet; also to improve the Shiawassee River from the Saginaw River to the Bad River; Bad River to the village of Saint Charles, and the Flint River from the Shiawassee as far as practicable, to such an extent as will afford a reliable navigation for light-draft boats between Saginaw River and the village of Saint Charles and on the Flint River as far as practicable.

The Saginaw River having been surveyed in 1895, it was not considered necessary for the purposes of the act to make a new survey of this stream, and field work was therefore confined to the Shiawassee, Bad, and Flint rivers; this was done during the winter of 1896–97, soundings being taken through the ice. The results of the surveys are shown in the ten tracings,* which are forwarded with this report in a separate roll.

Saginaw River.—Work for improving the Saginaw River from the bay to the city of Saginaw has been in progress since 1867, and a summary of results is given in the Annual Report of the Chief of Engineers, United States Army, for the year ending June 30, 1897.† The project under which operations have been carried on since 1882 has had for its object the making of a channel 200 feet wide, 14 feet deep, from Saginaw Bay to Bay City, and 12 feet deep from there to Saginaw. The scheme of improvement now suggested contemplates channels 2 feet deeper, and an extension of operations about 2½ miles farther upstream than any work thus far done. Experience shows the improved channels below Bay City to have had a fair degree of permanence, but those above that point much less so. This is in a measure due to the fact that it has not been possible, with the money appropriated, to complete any of the channels above Bay City to the full width of 200 feet, nor to half that width in most places. But even if all had been promptly dredged to the width called for by the project of improvement, it is quite certain that a large amount of dredging would have been required annually to maintain them.

The estimated cost of improving the river as now suggested in the river and harbor act of June 3, 1896, is $452,925 for the main channel of the river, and $29,700 for the west channel at West Bay City; in all, $482,625. The details of this estimate were prepared under the immediate directions of Lieut. James F. McIndoe, Corps of Engineers, and copy of his report is submitted herewith. It is proper to add that the improvement could not be completed on this estimate except with large appropriations, admitting of continuous work, and that the subsequent maintenance would probably call for an annual expenditure of $15,000 at least.

Shiawassee and Bad rivers.—Preliminary examinations of these streams were made in 1894, and my report thereon is printed in House Ex. Doc. No. 232, Fifty-third Congress, third session; also in the report of the Chief of Engineers, United States Army, for 1895, pages 2852–2853. The conclusion expressed in that report was that these streams are worthy of improvement to such extent as will afford a reliable navigation for light-draft boats between the village of St. Charles, on the Bad River, and Saginaw, at the mouth of the Shiawassee.

The estimated cost of this improvement, based on dredging a channel 50 feet wide and 6 feet deep, is $21,000 in round numbers, as detailed in Lieutenant McIndoe's report, which is transmitted herewith. A temporary improvement that would meet the immediate requirements of navigation within the proposed limits could probably be made with an expenditure of $5,000. The resulting navigable depth would be about 5 feet.

Flint River.—In my report on the preliminary examination of this stream the opinion was expressed that it was not worthy of improvement. This report is published in House Ex. Doc. No. 232, Fifty-third Congress, third session, and in the Report of the Chief of Engineers for 1895, page 2853.

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*Only three maps printed. † Page 3012.

The estimated cost of improving it, "as far as practicable," from its mouth, a distance of about 4 miles, by dredging a channel 50 feet wide and 6 feet deep, is $15,000 in round numbers.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF FIRST LIEUT. J. F. M'INDOE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., August 27, 1897.

COLONEL: I have the honor to transmit herewith detailed estimates of the cost of improving the Saginaw, Bad, Flint, and Shiawassee rivers, as called for by act of Congress June 3, 1896. These estimates were prepared under my direction by Assistant Engineer B. H. Muehle, and are based on surveys made in January and February, 1897.

In summarizing the estimates, I have reduced the cost of the Saginaw River improvement, believing that such reduction could be safely made, and I have added some general notes on the tributary streams.

(1) Saginaw River from its head to a point on Saginaw Bay.

(a) Dredging a channel 200 feet wide and 14 feet deep from head of river to Third Street Bridge, 1,235,000 cubic yards, scow measure, at 30 cents..	$370,500
(b) Dredging a channel 200 feet wide and 16 feet deep from Third Street Bridge to Saginaw Bay, 165,000 cubic yards, scow measure, at 25 cents..	41,250
Total for dredging	411,750
Add 10 per cent for contingencies	41,175
Total estimated cost of improvement	452,925

(2) West channel, Saginaw River, between Middle Ground and West Bay City.

Dredging a channel 75 feet wide and 14 feet deep, 90,000 cubic yards, scow measure, at 30 cents	$27,000
Add 10 per cent for contingencies	2,700
Total estimated cost of improvement	29,700

(3) Shiawassee River from the Saginaw River to the Bad River.

Length, 9.4 miles. Except for a short distance in the upper part of its course the Shiawassee flows through low and marshy land. From Saginaw River to Lake Shiawassee (9,230 feet) it has a width of about 300 feet and a least depth of about 8 feet in the channel, except in one place, where there is a depth of less than 6 feet. Shiawassee Lake is 13,800 feet long and from 350 to 2,000 feet wide. Through it the river meanders, the depth in some places being less than 4 feet. From the head of the lake to the mouth of the Flint River, a distance of 7,200 feet, the Shiawassee has a width of 100 to 200 feet, the least depth being 5 feet. Between the mouth of the Flint and the Bad River, a distance of 19,400 feet, the Shiawassee has a width of from 50 to 100 feet. In this stretch the river is very crooked, and there are many shoals upon which there is a depth of less than 4 feet. Most of the dredging to provide a channel 6 feet deep and 50 feet wide in the Shiawassee River would be confined to this section, and the material would probably have to be turned over, as the limits of the channel would scarcely allow the use of scows.

The estimate is as follows:

Dredging a channel 50 feet wide and 6 feet deep in the Shiawassee River from the Saginaw River to the Bad River, 94,500 cubic yards, scow measure, at 20 cents	$18,900
Add 10 per cent for contingencies	1,890
Total estimated cost of improvement	20,790

(4) Bad River to the village of St. Charles—distance 3.7 miles.

The characteristics of the Bad River are very different from those of the Shiawassee. It flows through a wooded country, has a width of 150 to 200 feet, and in its present condition there are only two places where dredging is needed to obtain a channel depth of 6 feet. Considered by itself, a channel at least 10 feet deep could be obtained by the expenditure of a very small appropriation. However, since it is a tributary of the Shiawassee, its improvement is limited to what is possible on the latter stream. For this reason an estimate is submitted for a channel of the same depth and width as the Shiawassee.

Dredging a channel 50 feet wide and 6 feet deep in the Bad River to the village of St. Charles, 1,000 cubic yards, scow measure, at 20 cents	$200
Add 10 per cent for contingencies	20
Total estimated cost of the improvement	220

The dredging needed in the Bad River is near its junction with the Shiawassee and must be done in connection with dredging the latter to allow the above low estimated cost.

(5) Flint River as far as practicable.

In the report on the preliminary examination of this river it was stated that it was not worthy of improvement. The following estimate is presented:

Dredging in Flint River, from its mouth 4 miles upstream, a channel 50 feet wide and 6 feet deep, 68,400 cubic yards, scow measure, at 20 cents	$13,680
Add 10 per cent for contingencies	1,368
Total estimated cost of improvement	15,048

Respectfully submitted.

J. F. McINDOE,
First Lieut., Corps of Engineers.

Lieut. Col. G. J. LYDECKER,
Corps of Engineers, U. S. A.

L L 21.

ESTIMATE OF COST OF IMPROVEMENT OF SAGINAW RIVER, MICHIGAN, FROM ITS HEAD TO A POINT IN SAGINAW BAY.

[Printed in Senate Doc. No. 218, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, March 24, 1898.

SIR: I have the honor to acknowledge reference to this office of resolution of the United States Senate of March 22, 1898, directing the Secretary of War—

to inform the Senate as to the cost of improving the Saginaw River from its head to a point in Saginaw Bay, with a view of securing a channel 150 feet wide and an increase of depth to 16 feet from the head of the river to the Third Street Bridge in Bay City; thence a channel 200 feet in width to the Saginaw Bay, with an increase of depth of the channel to 16 feet, said estimate to be based on the survey made pursuant to the river and harbor act of 1896.

In returning herewith the above-mentioned resolution of the Senate I have to state that the cost of securing a channel of the dimensions specified between the points named is estimated by Lieut. Col. G. J. Lydecker, Corps of Engineers, the local officer in charge of improvement of Saginaw River, to be $750,000 if the work is done under con-

inuing contract, and he states that the cost by any other method will e much greater and wholly indefinite.

While the resolution referred to this office is not such as is required y the provisions of section 4 of the river and harbor act of June 3, 896, which contemplates a concurrent resolution in such cases, it may e proper to remark that a concurrent resolution identical in language ith this has passed the Senate and was received in the House from e Senate March 21 and referred to the Committee on Rivers and arbors. (See Congressional Record, No. 73, pp. 3397 and 3398.)

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

L L 22.

URVEY OF ROUGE RIVER, MICHIGAN, FROM WABASH BRIDGE CROSSING TO MAPLES ROAD.

[Printed in House Doc. No. 138, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 6, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated November 20, 1897, with map,* by Lieut. Col. G. J. Lydecker, Corps of Engineers, upon a survey of Rouge River, Michigan, from Wabash Bridge crossing to Maples Road, with a view of obtaining a 16-foot depth of water, made to comply with the provisions of the river and harbor act of June 3, 1896.

No preliminary examination of this section of the river, with a view to improvement as above outlined, has ever been made by this office.

The cost of dredging a channel 75 feet wide and 16 feet deep is estimated at $33,000.

Lieutenant-Colonel Lydecker states that the only industrial establishment at present on this part of the stream is the Detroit Salt Company's works, located near its upper end, and, as the draft which vessels can now carry from the mouth of the river to the Wabash crossing is only about 13 feet, in his opinion the dredging of the shoaler portions in the upper part to such an extent only as would enable vessels that can now reach the Wabash crossing to get through to the salt works might meet all present requirements.

The cost of such dredging is estimated at $5,000.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

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*Not reprinted. Printed in House Doc. No. 138, Fifty-fifth Congress, second session.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., November 20, 1897.

GENERAL: I have the honor to submit the following report on a survey of the "Rouge River, Michigan, from Wabash Bridge crossing to Maples Road," made pursuant to instructions from the office of the Chief of Engineers, United States Army, to comply with the river and harbor act of June 3, 1896. A tracing of map of the survey is forwarded in a separate roll.

The Wabash crossing is about 2¾ miles above the mouth of the river, and this portion of the stream was improved by dredging a central channel 16 feet deep, 100 feet wide. This was done between 1888 and 1892, and since then the dredged channel has shoaled, so that the draft which vessels can now carry through it is reduced to about 13 feet.

The distance from the Wabash crossing to Maples Road is about 1¾ miles, and in this distance there are three quite sharp turns; the width between banks varies from 130 to 150 feet, and the general depth in mid-channel from 10 to 13 feet. Within these limits the river is spanned by two wooden bridges; one, at Fort street, has a narrow draw opening; the other, at Dix avenue, has no draw or other opening for the passage of vessels.

The act calls for the estimated cost of improving the specified section of river to a depth of 16 feet, but does not indicate any width for the improved channel. The cost will, of course, increase with the width, and the local conditions are such that this increase would be very rapid for widths exceeding 75 feet. Assuming, then, that the channel is to be 75 feet wide and 16 feet deep, the amount of material to be dredged will be, in round numbers, 120,000 cubic yards, bed measure. The cost of excavating and properly disposing of this material by the ordinary dredges used in this section of the country may be taken at 25 cents per cubic yard. The estimated cost of the improvement would therefore be $33,000, as follows:

Dredging 120,000 cubic yards, bed measure, at 25 cents	$30,000
Add 10 per cent for contingencies	3,000
Total	33,000

No preliminary examination of this section, or opinion as to the worthiness of improving it, has been called for by Congress, and therefore no opinion in that respect is submitted. But it seems proper to state that the only industrial establishment at present on this part of the stream is the Detroit Salt Company's works, located near its upper end. Copy of letter sent to me by the president of the company is herewith.

Considering all the facts in the case, I venture to suggest that instead of a radical improvement, at a cost of approximately $35,000, a less extensive scheme might meet all present requirements. This would be to dredge the shoaler portions to such extent only as would enable vessels that can now reach the Wabash crossing to get through to the salt works. This could probably be done at a cost of about $5,000.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

LETTER OF THE DETROIT SALT COMPANY.

DETROIT SALT COMPANY,
Detroit, Mich., June 4, 1897.

DEAR SIR: We are advised that you have completed the survey of the River Rouge to a point above our plant, in accordance with an act of Congress which made an appropriation for that purpose. Inasmuch as we are located the farthest up the Rouge River, we deem it advisable to write you in regard to our claim for an additional appropriation for the deepening of the channel of this river. At present we are manufacturing at this point 200,000 barrels of salt per annum, and are limited to the territory we reach by railroads on account of our inability to get boats to our plant.

At the time we located at this point, some two years ago, we were advised that the river had already been dredged to the Wabash Railroad, and that an appropriation had already been made for a turning basin above our plant, and that it was only a matter of a short time when this would be completed. There is no question that this entire territory is destined to be a large manufacturing district and will require water navigation; already there is a project on foot for the location of a salt mine a short distance from our works, with a capacity of 300 tons per day. The projectors of this enterprise have been assured that the Rouge would be dredged without a doubt, and, as we shall likely be interested in this mine, we are doubly interested in the opening of this river to navigation again, it having at one time been navigated as far as the town of Dearborn.

We already have our slip dredged ready for boats as soon as we can get them to our docks.

Very truly, yours,

DETROIT SALT CO.,
Per J. M. M.

Col. G. J. LYDECKER.

L L 23.

ESTABLISHMENT OF HARBOR LINES IN ST. CLAIR RIVER AT PORT HURON, MICH.

MAYOR'S OFFICE,
Port Huron, Mich., August 28, 1896.

DEAR SIR: The city of Port Huron respectfully requests authority from your Department for the construction of a dock in front of its property at the foot of Butler street, on the bank of St. Clair River, in accordance with the drawings hereto annexed.

* * * * * * *

We would also further request that your Department establish and permanently fix a dock line along the St. Clair River in front of the city of Port Huron, in accordance with the plan herewith submitted, or as near thereto as may be found best after an investigation thereof. If this could be done by your Department it would prevent hereafter any contention as to the construction or extension of docks along the river front.

Very truly, yours,

N. S. BOYNTON,
Mayor.

The SECRETARY OF WAR.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
November 10, 1896.

Respectfully referred to Lieut. Col. G. J. Lydecker, Corps of Engineers, for report.

To be returned.

A. MACKENZIE,
Acting Chief of Engineers.

[Third indorsement.]

U. S. ENGINEER OFFICE,
Detroit, Mich., November 21, 1896.

Respectfully returned to the Chief of Engineers, United States Army.

* * * * * * *

It is desirable that a limiting dock line along the city front of Port Huron be established, and that indicated on the tracing may be found to be a satisfactory one; but the matter can not be determined until more full examination than is practicable at this season. I therefore recommend that final action respecting the dock line be deferred until next spring, when we will have other work in progress in that locality, and all necessary investigation can be better and much more economically made.

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

[Eighth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
July 28, 1897.

Respectfully returned to the Secretary of War.

The city of Port Huron, Mich., has requested that a dock line be established by the Secretary of War along the city front on St. Clair River, and attention is invited to the fourth indorsement hereon, in which it was recommended that final action in the matter be deferred until the necessary investigation could be better and more economically made.

In a report of the 20th instant herewith, Lieutenant-Colonel Lydecker states that a full examination of the locality has been made, and recommends that the line shown in red on the accompanying tracing* be adopted as the harbor line along that part of the river.

It is recommended that the line selected be approved as a pierhead line, and that the Secretary place his approval both upon this paper and upon the chart submitted, which has been prepared for his signature.

A. MACKENZIE,
Acting Chief of Engineers.

[Ninth indorsement.]

WAR DEPARTMENT,
September 16, 1897.

Approved as recommended by the Chief of Engineers.

R. A. ALGER,
Secretary of War.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 20, 1897.

GENERAL: Referring to my indorsement dated November 21, 1896, upon application of city of Port Huron to establish a limiting dock line

*Not printed.

along the city front in St. Clair River, referred to me for report, I have the honor to state that I have recently had full examination made of the locality, and, as a result of this examination and personal observation, I now recommend that the dock line shown in red on the tracing submitted with above application and returned to the Department November 21, 1896, be formally adopted as the harbor line along that part of the river.

Very respectfully, your obedient servant,

G. J. LYDECKER,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

APPENDIX M M.

MPROVEMENT OF RIVERS AND HARBORS ON LAKE ERIE WEST OF ERIE, PENNSYLVANIA.

'PORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS, OFFICER IN 'HARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER)OCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

Monroe Harbor, Michigan.
Toledo Harbor, Ohio.
Port Clinton Harbor, Ohio.
Sandusky Harbor, Ohio.
Huron Harbor, Ohio.
Vermilion Harbor, Ohio.
Black River (Lorain) Harbor, Ohio.
8. Cleveland Harbor, Ohio.
9. Fairport Harbor, Ohio.
10. Ashtabula Harbor, Ohio.
11. Conneaut Harbor, Ohio.
12. Removing sunken vessels or craft obstructing or endangering navigation.

SURVEYS.

Monroe Harbor, Michigan.
Straight channel in Maumee River and Bay, Ohio.
Curve Island Reef, near South Bass Island, in Lake Erie, Ohio.
16. Bar at mouth of Sandusky Harbor, Ohio.
17. Black River (Lorain) Harbor, Ohio.
18. Breakwater at Cleveland Harbor, Ohio.

HARBOR LINES.

19. Sandusky Harbor, Ohio.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, July 19, 1898.

AL: I have the honor to forward herewith annual reports for my charge for fiscal year ending June 30, 1898.
the year Mr. William T. Blunt, assistant engineer, has given upervision to works of improvement in western portion of t and has conducted various special surveys. Mr. F. S. assistant engineer, has given personal supervision to works ortion of the district, and has specially assisted in the office.
respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

JOHN M. WILSON,
Chief of Engineers, U. S. A.

M M 1.

IMPROVEMENT OF MONROE HARBOR, MICHIGAN.

The project for improving the harbor of Monroe, Michigan, by cutting a straight canal across the marsh and protecting the end at the lake by piers, was completed in 1839, but the piers were extended somewhat farther in 1845. Since that date all expenditures upon the improvement have been for maintenance by repairs of piers and canal revetment and dredging the channel.

The total expenditure for construction and maintenance, 1835 to 1845, was	$110,000.00
For maintenance, 1845 to June 30, 1897	130,533.60

At the close of the last fiscal year the piers were in good condition, the superstructures having been rebuilt under appropriations of July 13, 1892, and August 18, 1894.

The act of June 3, 1896, appropriated $5,000 for "dredging the channel." Dredging the channel formed no part of any project of improvement, nor had it been recommended by the officer in charge of the improvement for reasons briefly set forth in the last annual report, as follows:

First. Soundings in November, 1896, show no perceptible change in the river channel during four years and no change in the bar at the entrance in more than one year.

Second. During the past eight years several surveys have been made, and they all show practically the same depths, except when made immediately after dredging.

Third. Additional depths obtained by dredging in the river in 1888 soon disappeared and the previous conditions returned.

Fourth. The bottom of river at the Monroe docks is of solid rock, with a depth of 8 to 9 feet of water.

Fifth. The channel depth in river and canals is everywhere greater than at the docks, and so remains from year to year.

Under date of August 21, 1897, proposals for dredging were invited by circular letter and poster for ten days. Proposals were opened August 31 and the work was awarded to the lowest bidder, Mr. M. J. Griffen, of Detroit, Mich., at 11½ cents per cubic yard of material, measured in scows.

It was estimated that the amount available would be sufficient to pay for dredging a channel 150 wide and 14 feet deep from the outer end of piers to a depth of 14 feet in the lake, a distance of about 1,800 feet, and the work was laid out accordingly.

Dredging with a very poor plant and an inexperienced crew was commenced September 9, 1897, and continued until October 13, when the dredge sunk in the lake on the side of the dredged channel and about 750 feet outside the end of piers.

November 1, 1897, dredging in the channel was resumed by a dredge plant hired by the contractor and was continued until November 30. The total amount of material dredged and removed in the three months was but 9,845 cubic yards, an amount entirely insufficient to make any noticeable improvement to the channel.

Under the circumstances the officer in charge of the improvement considered that the dredge should be removed by the contractor or at his expense. The dredge when put upon the work was entirely unworthy, and on the day before it sunk the contractor was notified by mail that it would no longer be permitted upon the work unless assisted by another and better machine. On the 19th of November the contractor was specially requested to remove the sunken dredge, and his reply indicated that the removal would be effected.

ayment for the small amount of material removed in November was efore delayed until June, 1898, to secure if possible the removal of wreck without expense to the United States. This having been d impracticable, the removal of the wreck by the United States er provision of section 4 of the river and harbor act of June 14, , has been authorized.

ıe unexpended balance of the appropriation for dredging is too ll to obtain any competition by advertising, or to obtain any prices onably low for doing the work by hiring a dredge plant. The mmendation of the officer in charge of the improvement that the ted States dredge plant pertaining to Toledo Harbor, Ohio, be loyed to complete the dredging as far as it may be done with avail- funds has been approved by the Chief of Engineers. The dredge ow engaged upon other work, but will go to Monroe as early in July racticable.

'hile no general conclusions can fairly be drawn from a single ance, it is nevertheless true that the work at Monroe fairly illus- es some of the phases of doing work by contract after advertising, cially in small amounts at places remote from large cities. In the er cases the lowest proposals are not infrequently the least desira- because they have been submitted by parties lacking in information, erience, judgment, or honesty, who bid low in order to obtain the ard and trust to blind fortune, shrewdness, or dishonesty to obtain rofit.

During a long experience, the writer of this report has not in a single tance failed to obtain better results both in price and quality when all works have been done by hired labor and purchase of materials open market for small amounts, or by contract for large amounts, an when similar work has been done by contract.

Under date of December 2, 1897, a report upon survey of harbor of Monroe, Mich., and an estimate of cost with a view to obtaining a 14- oot depth of water was submitted to the Chief of Engineers in compli- nce with requirements of the river and harbor act of June 3, 1896. The report was printed in House Doc. No. 102, Fifty-fifth Congress, second session, and a copy is appended to this report as Appendix M M 13.

The commerce of Monroe is very small and its location is such that there is no good reason to conclude that a greater depth of water would result in a very great benefit. The freight tonnage reported for 1897 s less than the annual average number of dollars expended for main- tenance since 1845. In 1896 freight tonnage was not reported. The registered tonnage covers the passenger excursion steamers running in summer months for pleasure travel to the canal and piers but not to the city of Monroe.

Monroe is in the collection district of Detroit, Mich. There is a light-house on the outer end of north pier.

Money statement.

July 1, 1897, balance unexpended	$4,981.67
June 30, 1898, amount expended during fiscal year	1,537.93
July 1, 1898, balance unexpended	3,443.74
Amount (estimated) required for completion of existing project	11,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	11,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Amount and date of all appropriations for improving the harbor of Monroe, Mich.

February 24, 1835	$30,000.00	March 3, 1881	$1,000.00
July 2, 1836	15,000.00	August 2, 1882	1,000.00
March 3, 1837	30,000.00	August 5, 1886	2,000.00
July 7, 1838	15,000.00	August 11, 1888	5,000.00
June 11, 1844	20,000.00	September 19, 1890	5,000.00
August 30, 1852	14,000.00	July 13, 1892	10,000.00
June 23, 1866	31,015.27	August 18, 1894	5,000.00
June 10, 1872	10,000.00	June 3, 1896	5,000.00
March 3, 1873	15,000.00		
June 23, 1874	10,000.00	Total	245,515.27
March 3, 1875	10,000.00	Amount expended to June 30, 1898	242,071.53
August 14, 1876	5,000.00		
June 8, 1878	2,500.00	Balance unexpended July 1, 1898	3,443.74
March 3, 1879	2,000.00		
June 14, 1880	2,000.00		

COMMERCIAL STATISTICS.

The following statistics for the year 1897, relative to the commerce of the harbor of Monroe, Mich., were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Poles	325	Logs	200
Merchandise	100	Merchandise	100
		Fish	1,000
Total	425	Total	1,300

Total freight tonnage:

1897	1,725
1896	No report

Vessels.	Number.	Tonnage.
Entering	245	11,180
Departing	245	11,180
Built	1	15

Total registered tonnage (vessels entering and departing):

1897	22,360
1896	No report

Draft of largest vessels using harbor, 10 feet. Largest vessels do not load to full depth. No new vessel lines established during the year.

M M 2.

IMPROVEMENT OF TOLEDO HARBOR, OHIO.

The harbor of Toledo, Ohio, is mainly formed by that part of the Maumee River which is from 4 miles to 7 miles above its mouth at the head of Maumee Bay.

Originally, most of the river channel from the upper part of the harbor to the lake was amply deep, but there were shoals where the depths were from 14 feet to 16 feet. The channels in the bay, however, were

ore shallow, and for several miles the depths in those channels ranged
om 8.5 to 12 feet.

The first improvements undertaken were under provisions of the river
d harbor act of June 23, 1866. The project was to secure a depth of
feet from the river to the lake through the best natural channels.
iis project was amended from time to time as greater depths became
cessary until 1887, when the channels in the bay had been dredged
a depth of 16 feet, though the minimum depths were slightly less.

The project adopted in 1887 was for a straight channel from the
outh of the river 200 feet wide and 17 feet deep to the lake, a distance
proximately 7½ miles. The old channel was utilized as far as pos-
ble, which was over a length of a little more than 2 miles near the
iddle of the bay. The estimate of cost was not made in detail, but
as made on the basis of its length and the cost per unit of length for
milar works elsewhere. On the supposition that dikes or piers might
e required to protect the channel, the estimate of cost was $1,875,000.

The project was subsequently modified by increasing the width pro-
osed for the outer division of straight channel, a length of about 3
iles, to 300 feet, and by extending the improvement to include the
Iaumee River, where shoals known as "The Crossing" and the "Lake
hore Shoal," each about 4,000 feet long, have been dredged to a depth
f 18 feet over a width of 400 feet, and some work has been done at
other places.

It has been found inadvisable to build dikes over more than a por-
tion of the distance traversed by the channel, and it is quite probable
that with additional widths it may ultimately cost no more to maintain
the channel than the amount which would come from a low rate of
interest upon the estimated cost of dikes. At the lake end of the
channel, however, low dikes might be so arranged as to serve as break-
waters to reduce the sea, so that the entire depth of channel may be
utilized. In other words, dikes to reduce the sea from the lake would
be equivalent to adding several feet to the depth of the channel.

By abandoning the construction of dikes as proposed, the cost has
been greatly reduced, so that, although the original project has been
much extended in length and width of channels and they have been
dredged several times as a matter of maintenance and have thus had
the depths increased, no additions have been made to the original
estimate. There is a large balance of the original estimate for com-
pletion of the project.

At the beginning of the last fiscal year work of dredging was in
progress under a contract to widen the outer end of straight channel,
cut a new turn-out channel on southerly side of range beacons in the
bay, and such other dredging as might be needed.

The contract was completed June 11, 1898, resulting in widening the
outer division of channel to 300 feet on bottom as planned, completing
southerly channel of turn-out section 200 feet wide, and dredging cuts
near each bank of the channel inside turn-out over a length of about
1,600 feet. The depths were made 18 to 20 feet. The amount dredged
under this contract during the fiscal year was 643,058 cubic yards;
entire amount dredged under the contract was 869,358 cubic yards.

The United States dredge and plant completed the channel over the
"Crossing," removed part of shoal near foot of Buffalo street, and
widened and deepened the upper end of straight channel. The dredge
has been employed much of the time at other harbors when it was too
difficult or expensive to do the work by other means, and in this way
its services have been of very great value to the respective improve-

ments, and it has not in any way injured the interests of Toledo Harbor.

Under the last appropriation for improving Toledo Harbor, the United States dredge has done the work, which would have been most expensive by contract because of the exceedingly long distances to tow and the constant interruptions by passing steamers. The total amount dredged at Toledo Harbor in two years by the United States dredge has been, for reasons given, but 191,789 cubic yards. The entire cost of this dredging, including ordinary and extraordinary repairs to dredge, tug, and scows, and all cost of superintendence and care for two years, has amounted to $33,158. The cost per cubic yard has therefore exceeded 17 cents, but it is not probable that the same work in the same places could have been done by contract, including superintendence, at a less rate; the effect of having the dredge at command for all occasions has been very beneficial.

A suitable wharf and storehouse at Toledo has for several years been a necessity, and it at last became well-nigh indispensable. A suitable location has therefore been leased, a substantial wharf has been constructed, and a good storehouse 24 feet by 48 feet in plan has been erected and covered with corrugated iron. All public property in old leased storeroom has been transferred to the new storehouse. The slip alongside of wharf has been dredged to afford ample width and depth in which to store steamers, dredge, and scows.

It has for several years been apparent that the steamer *Swansea*, which has been hired for use in superintending works in this district and in making surveys, was becoming too old and unseaworthy to be prudently retained in the service.

Authority was therefore obtained to purchase a more suitable steamer, and on November 30, 1897, the steamer *Visitor*, having a steel hull and triple-expansion engines, was purchased for the purpose at a cost of $14,000. The expense has been allotted to various harbors in the district as nearly as practicable in proportion to the service they require and received. For the superintendence and surveys required in connection with channels in Maumee Bay, the use of a steamer is indispensable, and the greater portion of its time is required in that location. Other works in the district, however, receive considerable benefit and have therefore paid a part of the expense.

During the winter the cabin of steamer *Visitor* was entirely removed and replaced with another adapted to the service, at a cost of about $4,000. The steamer, though small, is admirably adapted to the work for which it is needed.

The sundry civil act approved June 4, 1897, required "a survey and estimate of cost of deepening and widening the straight channel in Maumee River and Bay, with a view to obtaining and permanently securing a channel of a uniform width of 400 feet and 20 feet deep at low water, the cost of said survey to be paid out of money already appropriated for the improvement of said channel."

Mr. Wm. T. Blunt, United States assistant engineer, with a party on the steamer *Swansea*, was engaged in making the survey at such times as could be spared from other work on hand from July 24 to October 26, 1897. A complete report with map and estimate was submitted to the Chief of Engineers December 16, 1897. The report was published in House Doc. No. 198, Fifty-fifth Congress, second session, and a copy is appended hereto as Appendix M M 14.

The estimated cost of the improvements required is $1,095,000, on the basis of immediate completion. It is estimated that the cost of

ance during five years after completion will be $150,000, and
al cost of $20,000 thereafter, provided the work is done by a
ant belonging to the United States. Attention is invited to
plete report.

eport of Mr. Wm. T. Blunt, United States assistant engineer,
s appended hereto, gives an account of work done at Toledo
during the fiscal year; it also includes a series of reductions of
igs in the channel in tabulated form showing the annual changes
nd scour in various sections. These tables are of much value
rtaining the principles governing the fill and scour in the chan-
ıey show the conditions at periods in each year since the
t channel was commenced.

Blunt's report also refers to the beneficial effect resulting from
plication of rules and regulations issued by the Secretary of
ır the preservation of the straight channel and the benefit of
tion.

› is in the collection district of Miami, Ohio. There are two lights of the
ler at the mouth of the river, forming a range for inner portion of channel.
ı towers have recently been completed at the turn-out in the middle of bay,
l to exhibit three lights, so that there is a range in both directions. There
light of fourth order on Turtle Island as a guide to old channel. Congress
ıorized the construction of a new light-house at the outer end of straight

›mmerce of Toledo is increasing.

Money statement.

897, balance unexpended	$123,408.28
1898, amount expended during fiscal year	113,029.33
898, balance unexpended	10,378.95
898, outstanding liabilities	505.21
898, balance available	9,873.74
nt (estimated) required for completion of existing project	980,000.00
nt that can be profitably expended in fiscal year ending June 30, 1900	300,000.00

itted in compliance with requirements of sections 2 of river and
bor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Amount and date of all appropriations for improving Toledo Harbor, Ohio.

OLD CHANNEL.

3, 1866	$20,000.00	March 3, 1879	$20,000.00
2, 1867	20,000.00	June 14, 1880	30,000.00
0, 1869	29,700.00	March 3, 1881	40,000.00
1, 1870	50,000.00	August 2, 1882	50,000.00
3, 1871	50,000.00	July 5, 1884	20,000.00
0, 1872	15,000.00	August 5, 1886 (see note)	9,632.61
3, 1873	100,000.00	August 11, 1888	5,000.00
3, 1874	75,000.00	September 19, 1890	5,000.00
3, 1875	75,000.00		
t 14, 1876	60,000.00	Total for old channel	724,332.61
8, 1878	50,000.00		

ropriations for straight channel have been as follows:

, 1884	$25,000.00
t amount appropriated for old channel (see note)	9,632.61
	15,367.39
t 5, 1886	112,500.00
t 11, 1888	150,000.00
ıber 19, 1890	200,000.00

July 13, 1892	$200,000.00
August 18, 1894	70,000.00
June 3, 1896	150,000.00
Total for straight channel	897,867.39
Total of all appropriations for Toledo Harbor	1,622,200.00
Total expended to June 30, 1898	1,611,821.05
Balance unexpended July 1, 1898	10,378.95

NOTE.—By act of August 5, 1886, the balance then available of the $25,000 appropriated July 5, 1884, for straight channel was made available for clearing the old channel.

LIST OF CONTRACTS FOR IMPROVING HARBOR AT TOLEDO, OHIO, IN FORCE DURING THE FISCAL YEAR ENDING JUNE 30, 1898.

Contract for dredging in straight channel through Maumee Bay.

Name of contractor, G. H. Breymann & Bros., Toledo, Ohio; date of contract, September 18, 1896; date of approval, October 3, 1896; date of commencement, October 6, 1896; date of completion, June 11, 1898.

COMMERCIAL STATISTICS.

The following statistics for the year 1887 relative to the commerce of the harbor of Toledo, Ohio, were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Iron ore	417,721	Coal	935,534
Coal	89,305	Corn	130,118
Lumber	149,107	Wheat	226,030
Sand	98,432	Flour	48,213
Logs	42,400	Timber	40,548
Sugar	33,850	Rye	21,148
Flaxseed	23,266	Oats	7,086
Salt	14,055	Merchandise	60,915
Wheat	11,400		
Laths	10,892		
Plaster	9,555		
Shingles	1,451		
Fish	959		
Posts	275		
Merchandise	37,334		
Total	940,002	Total	1,469,592

Total freight tonnage:	
1897	2,409,594
1896	2,154,728
Increase	254,866

Vessels.	Number.	Tonnage.
Entering	2,409	1,251,241
Departing	2,407	1,240,803
Built	1	13.70

Total registered tonnage (vessels entering and departing):	
1897	2,492,044
1896	2,252,394
Increase	239,650

Draft of largest vessels using harbor, 20 feet. Largest vessels do not load to full depth. No new vessel lines established during the year.

REPORT OF MR. WILLIAM T. BLUNT, ASSISTANT ENGINEER.

ON BOARD U. S. ENGINEER STEAMER VISITOR,
Toledo, Ohio, June 30, 1898.

SIR: I have the honor to submit the following notes upon the work in Toledo Harbor during the fiscal year:

All depths mentioned are given at mean level of Lake Erie 1860 to 1875, the water during the fall of 1897 having been from a few tenths to 1 foot below mean level and during this season about at mean level.

In the summer and fall of 1897 the improved channels were sounded, with the exception of the Lake Shore Shoal, as called for in the sundry civil act of June 4, 1897. A special report was made upon this work under date November 29, 1897.

In May, 1898, these channels were again sounded for the purpose of this annual report. The channels throughout are in excellent condition when referred to a depth of 17 feet at mean level.

MAUMEE RIVER.

Lake Shore Shoal.—The dredging of this reach was completed August 13, 1896, leaving a depth of 19 to 20 feet. No regular soundings have been taken since those of May, 1897, which showed depths to remain nearly as dredged. Occasional random soundings are all I have been able to obtain thus far, but no trouble has developed to deep-laden boats.

Lower Crossing.—At date of last annual report the U. S. dredge *Maumee* was engaged in completing the full width of 400 feet. This was accomplished September 14, 1897, nearly 43,000 yards having been removed in the widening of about 100 feet from June 5, 1897, to September 14, 1897.

Soundings were taken October 25, 1897, over the southerly half, to show results of this dredging. Again on May 27, 1898, the entire width was sounded.

In the table following I have rearranged the average soundings heretofore published so as to conform to the new arrangement of the straight channel tables. The channel is divided longitudinally into intervals of 20 feet width, and the average depth in each interval for the entire length of cut is determined from each survey. The intervals are numbered east and west from the axis, thus allowing for any future widening without altering the form of table.

As the first dredging was done in 1894 over a width of 300 feet, and that portion has not since been disturbed excepting where the two works overlapped, comparisons can be made from five surveys, extending over a period of nearly four years uninfluenced by dredging. The results are quite irregular, as might be expected, considering the many influences at work in an arm of the lake with no regular current and with a soft movable bottom easily disturbed by the passage of large boats. The causes operating to make a fill or a scour are so varied and discordant, that when the change is so small as a few hundredths or even tenths of a foot, unless showing some regularity of operation, it is quite useless to look for a cause or to attempt to foretell what may happen in the future. At present we can only record the changes as they occur and by general averages gather some idea of the action.

The first two years showed practically no resultant fill on the portion then completed. The third year showed a resultant fill of over four-tenths of a foot, extending more or less over the entire width of cut and being heaviest along the west edge. The fourth year again showed practically no change, the actual figures indicating a slight resultant scour. The average of all total deposits for the period 1894 to 1898, in such intervals as were dredged in 1894, is 0.54 foot, giving an average annual rate of 0.15 foot.

Over the portion dredged in 1897 the surveys of October, 1897, and May, 1898, indicate an average fill of one-half foot, whereas over the portion dredged in 1894 the first two surveys showed practically no fill. This was probably due to the fact that the 1894 cut opened up the channel to such a width that the current maintained the depth, while the present width has reached beyond that power, and the tendency is to even up the latest disturbance.

Parties owning the river banks along this reach have recently taken the initial steps toward filling out to the harbor line. The Pennsylvania Company has built a solid wharf and slip near the foot of Ash street, extending to the harbor line and at present covering a total frontage of 350 feet. The Craig Ship Building Company has extended its large wharf to the harbor line, with a frontage of 200 feet. The park commissioners of the city of Toledo are now constructing a revetment nearly out to the harbor line, as a step toward the improvement of the entire Riverside Park frontage, by constructing islands and lagoons on the flats. It is quite probable that these improvements will act as an incentive to the further reclamation of the flats, and

thus form a rectified bank line which must act toward the natural maintenance of the Lower Crossing depths.

Buffalo Street Shoal.—During the season of 1897 deep-draft boats experienced trouble in the natural channel off Buffalo street, where the middle-ground contours bulge quite materially toward the channel. The disturbance of bottom by boats aground on the east bank threw up lumps, which became more troublesome and extensive until finally, with low water of the fall, it was almost impossible to pass with 17-feet draft. The dredge *Maumee* was directed to open the channel, and from November 16 to 27 removed 8,434 yards. On May 9, 1898, work was resumed, and 4,350 yards removed up to May 13, when the services of the dredge were required at other harbors. The channel has been cleared for a width of 310 feet, and is now sufficient for the immediate needs of navigation.

Mooring basin.—Authority having been granted for the lease of the riparian privilege controlled by the Toledo and Ohio Central Railway Company just north of Cherry Street Bridge on east side of river, to be used as a mooring basin for the floating plant and for the construction of wharf and storehouse, the dredge *Maumee* was occupied from November 27 to December 4 in dredging the basin for the proper and safe accommodation of the fleet through the winter. Work was resumed April 19, 1898, and on May 4 an area 400 by 150 feet had been cleared to a depth of 14 feet by the removal of 17,079 yards.

A pile wharf 36 by 90 feet was built during the winter and a storehouse 24 by 48 feet was erected upon it, at a total cost of $2,000 for both. A line of mooring piles was driven in the basin—four single and two clusters of three each. The basin is now in excellent shape for the accommodation of plant, and is unusually safe from flood or fire by reason of the protection afforded by the high embankment of the bridge approach and the isolation from other buildings.

STRAIGHT CHANNEL.

Dredge Maumee, river division.—From September 15 to November 15, 1897, the dredge *Maumee* was engaged in redredging the enlarged entrance of the straight channel at mouth of river. This had been dredged for the first and only time in 1891 and 1892, under contract of L. P. & J. A. Smith. To facilitate the entrance of boats it was deemed advisable to deepen this area; 58,759 yards were removed with resultant depths of 18 to 20 feet.

Contract, George H. Breymann & Bros.—At the close of the last fiscal year the widening on the north side of outer division was nearly completed and that on south side was begun. Three dredges were continued on the contract until September 3, when one was withdrawn; the other two continued until the 24th and 30th of November, respectively. Work was resumed on May 2, 1898, with one dredge, which exhausted the available funds on June 11 and contract was declared closed, 837,400 cubic yards having been removed.

The outer division of straight channel from cribs to lake was widened 50 feet on each side, leaving it now 300 feet wide at bottom. Nearly the entire width of the channel was dredged, owing to the necessity of removing the ridges thrown up in widening.

The south turn-out around cribs was dredged to a width of 200 feet, according to the original plan, for the first time, so that now there are two channels of 200 feet width each around the cribs, with easy approaches. These approaches will be hardly noticeable should the project for 400 feet width be adopted. The extreme width over all at turn-out being 480 feet, the slant will be but 40 feet on each side, distributed over a length of 800 feet.

Upon completion of south turn-out the dredging was continued inside the cribs along the edges of the channel, removing the fill from each side and one cut from the south bank through sections 2 and 3.

Condition of the channel.—In recent Annual Reports some general comparisons have been made of depths found by various surveys, with a view to determining the rates of deposit in the various parts of the channel. I have never been able to spare the time necessary to obtain the results in detail for each section. Since the appointment of Mr. Thos. W. Bodley as recorder in November last, this and other detail work has been accomplished. I am able to present as a part of this report a full set of tables showing average depths at various times in longitudinal strips of 10 feet width for each section of 800 feet length.

For convenient reference, the channel has been from its inception divided into the inner, middle, and outer divisions. These are again divided into sections of 800 feet length. The outer and middle divisions join at the old position of the main crib light, and their sections are numbered respectively outward and inward from it. The middle and inner divisions join at the junction of the crib range and the old

outer range, 11,644 feet from the crib. The sections of the inner division are numbered from this position inward to the Maumee River, a distance of about 12,000 feet. The tables are arranged in order from the river outward to the lake. The portion of channel in the immediate vicinity of the cribs, commonly called the "turnout," has been omitted entirely, as it has always been subject to desultory dredging and natural changes not proper to be considered in this comparison; otherwise the tabular comparisons are complete and continuous for the entire length of channel. Until the spring of 1894 the improvement was not continued beyond section 20, outer division, so that the regular comparison for general averages stops with that section.

The longitudinal intervals of 10 feet width above mentioned are numbered north and south from the axis of channel. An average depth is deduced for each of these intervals in each section and from each survey of record since the channel was adopted. In columns between the different surveys are noted the deposits due to the period of time and their averages, or the records of dredging done during the period. Under the averages are shown the annual rates of deposits indicated thereby.

In a table of summaries are shown those annual rates for different periods and for each section, with their general averages for periods and for sections, and a grand average for each division.

On the general chart appended are shown the location of divisions and sections, together with a graphic illustration by curves of the annual rates for different periods of time and the curve of the means of all annual rates.

These tables thus give a complete history of each section of the straight channel, beginning with its depth before the improvement was entered upon.

A glance at the detail results of these tables will show the futility of attempting to reconcile their wide variations. They are so erratic throughout that I see no possible data upon which to base a theory for any one portion of channel. Some of the elements which control the action of deposits and the results of comparison are:

The general depth to which cuts are made.

The season of year when cuts are made.

The actual time elapsing between dredging and first soundings.

The actual annual rates for each year when more than one year elapsed between soundings.

The stage of water during the period of deposit.

The proportional number and character of boat passages for each period.

The conditions of rainfall, evaporation, winds, and consequent currents.

Errors in reduction to mean level when water surface is changing rapidly and in reading of sounding rod itself in a choppy sea.

I believe the errors of location, platting, and tabulation are practically eliminated in the averages, but the other controlling conditions are so varied and yet so influential as to make futile any attempt to evolve a law without knowledge of these conditions. Most of these conditions can be determined, but the proper application of them in the problem will be a tedious and intricate work, hardly justified by the object to be gained.

Extremes of deposit and scour often occur in the same or contiguous sections, as, for instance, sections 10 and 11, inner division; sections 12 and 13 and section 9, middle division; section 9 and sections 16, 17, and 18, outer division.

Passing to the means of all annual rates in each section, the range of variation decreases materially and the grand means for the divisions are: Inner, 0.45; middle, 0.45, and outer, 0.48 foot, agreeing very closely with each other. This agreement of grand averages in the three divisions indicates that the resultant of all influences acting on the channel, including that of occasional dredging, will in a series of years show an average annual fill of about 0.45 foot over each division of the channel, varying from 0.2 foot to 0.7 foot in sectional averages.

The curves of annual deposit indicate that any one period may show an annual rate of deposit over any section varying from 0.6 foot to 1.5 feet.

The tabular means of longitudinal intervals of sections indicate that the actual deposits are generally largest along the edges of channel and smallest along the middle. A scour along the middle of channel does not necessarily indicate an actual removal of original bottom, but rather a removal of the loose material left there by dredging operations. In my annual report for 1894 it was noted that dredging to a required depth on dipper arm leaves on the average three-fourths of a foot less depth, and soundings taken immediately after dredging show depth to this soft broken-stone and not to the firm, untouched bottom. Over nearly the entire length of channel the dredged bottom is of hard clay, capable of resisting any action of nature, and the depths after scour do not exceed those previously reached by the dredge.

An apparent scour is, therefore, generally only a transfer of material from the middle of the channel to its sides, due to the action of propeller wheels acting within the axial range. Near the outer end of channel, where clay bottom is not

reached by dredging, an actual scour of the sand formation undoubtedly does tak place, as indicated in table.

The present practical condition of channel is about as follows:

Through the inner division the depth is nowhere less than 16 feet within the 200 feet width. In but small areas along the edges is it less than 17 feet, and the genera depth along the axis is 18 feet or more.

Through the middle division the depth along the edges is occasionally a few tenths less than 16 feet, the area having less than 17 feet being very small until nea the outer end, when for about 2,000 feet of length the 17-foot channel is about 10 feet wide. Depths along the axis are generally more than 18 feet.

Through the south turn-out depths are generally 19 to 21 feet, owing to the recen dredging.

Through the outer division for full 300 feet width the depths are never less tha 17 feet, very few are less than 18 feet, and generally run from 18 to 20 feet.

Old piling.—The old broken piles between the crib lights are gradually disappear ing. They break off near the bottom, drift into the channel, and are a menace t boats until found and dragged into shoal water. Each year, recently, I have remove many of them.

Rules and regulations.—As custodian of the straight channel under the rules an regulations signed by the Secretary of War, to be effective from and after July 1 1897, I have given considerable attention to the enforcing of the regulations. Durin June, 1897, special care was taken to place copies of the rules on all boats regularly using the straight channel and to post them in conspicuous places.

I take great satisfaction in reporting that generally all captains have endeavored to comply with the various requirements. In only a few instances has a definite warning been necessary, and in no case have I found it necessary to report a case for action to convict. No serious accidents or other emergency cases have occurred to require extraordinary action under the rules.

I feel sure that the limiting of speed through the straight channel to eight miles per hour has materially aided in keeping the channel clear of deposits. While large sidewheel boats passed through at a speed of 12 to 14 miles per hour, they carried with them a very heavy combing wave, which washed the material from the adjacen flats into the channel.

STEAMER VISITOR.

The chartered steamer *Swansea* was retained upon the work until the close o season of 1897, having been in almost continuous service since the spring of 1889 The steel steamer *Visitor*, purchased by you in November, 1897, was delivered la in November and was placed with the rest of the fleet in winter quarters. Durin the winter her cabins were remodeled to suit the necessities of the work, unde special authority for expenditure of $2,500. By using care and economy, the expense of alterations and outfit was kept within this limit. The steamer ha given excellent satisfaction thus far and is all that can be desired as a working boat. One statement is indicative of the whole—while she is running 12½ or 13 miles per hour in a seaway I can continue detail drafting at the table.

EMPLOYEES.

I beg in conclusion to testify to the faithful and efficient services of the employees under my immediate supervision, and more especially to those of Mr. Adolph Koch, inspector in charge of U. S. dredge *Maumee*, Mr. J. T. Holling, senior inspector of contract dredging, Capt. A. A. Stevenson, master of steamer *Visitor*, and Mr. Thos. W. Bodley, recorder, all of whom exhibit the greatest interest in their work and the disposition to aid materially in carrying out your orders for the best interest of the United States.

Very respectfully,

WM. T. BLUNT,
United States Assistant Engineer.

Col. JARED A. SMITH,
Corps of Engineers, U. S. A.

Maumee River—Lower crossing.

[Original channel 15 to 17 feet deep, irregular. Dredged in 1894, 300 feet wide.]

20-foot intervals from axis.	Aug. and Oct., 1894.	Deposit.	May 2, 1895.	Deposit.	May 13, 1896.	Deposit.	May 19, 1897.	Deposit.	Oct., 1897.	Deposit.	May 27, 1898.	Total, 44 mos.
West 10	19.9	—0.1	20	0.4	19.6	1.3	18.3	—0.2	.....	.....	18.5	1.4
9	20.1	—.1	20.2	.1	20.1	1.2	18.9	.0	.....	.....	18.9	1.2
8	19.7	—.2	19.5	—.3	19.8	.9	18.9	—.1	.....	.....	19	.7
7	19.7	—.1	19.8	.1	19.7	.7	19.0	—.1	.....	.....	19.1	.6
6	19.9	.0	19.9	.2	19.7	.4	19.3	—.1	.....	.....	19.4	.5
5	19.9	.0	19.9	.2	19.7	.2	19.5	.0	.....	.....	19.5	.4
4	20.2	.1	20.1	.2	19.9	.2	19.7	.0	.....	.....	19.7	.5
3	20.2	.2	20	—.1	20.1	.2	19.9	.2	.....	.....	19.7	.5
2	19.9	—.2	20.1	.1	20	.1	19.9	.2	.....	.....	19.7	.2
1	20.2	.2	20	.1	19.9	.3	19.6	.0	.....	.....	19.6	.6
East 1	(a)	(a)	19.3	—.1	19.4	.0	19.4	.2	.....	.....	19.2	.1
2	(a)	(a)	19.2	.2	19	—.2	19.2	.2	.....	.....	19	.2
3	(a)	(a)	19.4	.2	19.2	.1	19.1	.1	.....	.....	19	.4
4	(a)	(a)	19.4	.2	19.2	.1	19.1	—.1	.....	.....	19.2	.2
5	(a)	(a)	19.4	.0	19.4	.6	18.8	(b)	19.5	.6	18.9	.....
6	(a)	(a)	.....	.....	.....	.....	.....	(b)	19.2	.2	19	.....
7	(a)	(a)	.....	.....	.....	.....	.....	(b)	19.8	.6	19.2	.....
8	(a)	(a)	.....	.....	.....	.....	.....	(b)	20.2	.9	19.3	.....
9	(a)	(a)	.....	.....	.....	.....	.....	(b)	20.6	.6	20	.....
10	(a)	(a)	.....	.....	.....	.....	.....	(b)	19.6	.1	19.5	.....
Average deposit	.....	.02	.....	.10	.....	.41	.....	—.02	.....	.....	.....	.54
Annual rate	.....	.03	.....	.10	.....	.41	.....	—.02	.....	.....	.....	.15

a Dredging in progress. b Dredged in 1897.

Inner division, section 15.

[May and June, 1887, average depth before dredging, 8.7. Two cuts, Sept., 1887; dredging completed 200 feet Apr. to Oct., 1888.]

18-foot intervals from axis.	Nov. 19, 1888.		June 11, 1890.	Deposit.	June, 1892.		Nov. 29, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May, 1898.
North 10	13.8	Dredged May and June, 1890.	16.2	0.3	15.9	Dredged in fall, 1895.	20.1	0.5	19.6	Wid'n'd Sept., 96	18.5	—.1	18.6	0.2	18.4
9	15.4		16.7	.5	16.2		20.1	.0	20.1		18.2	.3	17.9	.1	17.8
8	16.1		17	.8	16.2		20	—.1	20.1		17.8	.1	17.7	.0	17.7
7	16		17.1	.8	16.3		19	—.5	19.5		17.7	.1	17.6	—.1	17.7
6	15.4		17.4	.7	16.7		17.9	.3	17.6	.4	18	.4	17.6	.0	17.6
5	15.1		17.4	.2	17.2		18.7	.5	18.2	.1	18.3	.6	17.7	—.1	17.8
4	15.1		17.4	—.1	17.5		18.6	.3	18.3	.3	18.6	.5	18.1	.2	17.9
3	14.5		17.3	—.3	17.6		19.2	.4	18.8	.1	18.9	.5	18.4	.0	18.4
2	14		17.2	—.4	17.6		19.1	.2	18.9	.2	19.1	.4	18.7	.0	18.7
1	13.9		17.1	—.4	17.5		19.5	.2	19.3	.1	19.2	.1	19.1	.2	18.9
South 1	14.2		17.4	.1	17.3		19.5	.5	19	.2	19.2		19.1	—.1	19.2
2	14.1		17.6	.5	17.1		19.3	.4	18.9	.3	19.2		19.1	—.1	19.2
3	14.2		17.4	.2	17.2		19.5	.5	19	.2	19.2		19.1	.0	19.1
4	14.7		17.3	.0	17.3		19.4	.4	19	.2	19.2		19.1	.0	19.1
5	14.6		17.3	.2	17.1		19.8	.7	19.1	.1	19.2		19.2	.1	19.1
6	14.5		17.3	.4	16.9		19.6	.6	19	.1	19.1		19.2	.0	19.2
7	15		17.3	.4	16.9		19.4	.5	18.9	.0	18.9		19.4	.2	19.2
8	15.3		17.4	.6	16.8		19.7	.5	19.2	.4	18.8		19.2	.2	19
9	14.5		17.4	.8	16.6		19.5	.5	19	.4	18.6		19.2	.4	18.8
10	14.7		16.9	.5	16.4		19.3	.8	18.5	.0	18.5		19.4	.2	19.2
Average deposit	.....	.....	.....	.29	.....	.....	.....	.36	.....	—.08	.....	.29	.....	.07	.....
Annual rate	.....	.....	.....	.14	.....	.....	.....	.62	.....	—.08	.....	.87	.....	.12	.....

Inner division, section 14.

[May and June, 1887, average depth before dredging, 6.4. Two cuts, Sept. and Oct., 1887; d completed 200 feet May to Oct., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		June 9, 1890.	Deposit.	June, 1892.		Nov. 29, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.
North 10	10.5	Dredged May and June, 1890.	16.5	1.7	14.8	Dredged in fall, 1895.	20.5	0.9	19.6	Widened Sept., 96	18.4	0.0	18.4	0.
9	14.2		16.8	1.5	15.3		20.6	1.0	19.6		18.1	.3	17.8	.
8	15.5		16.7	1.3	15.4		20.2	.5	19.7		18.3	.4	17.9	.
7	15.1		16.5	.7	15.8		18.3	.3	18.6		18.2	.5	17.7	.
6	14.1		16.5	.6	15.9		18	.4	17.6		17.9	.2	17.7	.
5	14.0		16.3	.1	16.2		18.4	.3	18.1		18.4	.3	18.1	.
4	14.1		16.3	.0	16.3		18.4	.3	18.7		19	.5	18.5	.
3	13.2		16.6	.3	16.3		18.8	.2	19		19.4	.2	19.2	.
2	12.8		16.2	.3	16.5		19.3	.2	19.1	.6	19.7	.3	19.4	.
1	12.0		16.3	.2	16.5		19.6	.4	19.2	.3	19.5	.1	19.4	.
South 1	14.2		16.4	.2	16.6		19.5	.0	19.5	.1	19.6		19.5	
2	12.4		16.6	.1	16.5		19.6	.4	19.2	.5	19.7		19.3	
3	12.4		16.8	.3	16.5		19.6	.2	19.4	.1	19.5		19.4	
4	13.3		16.9	.5	16.4		19.3	.1	19.2	.2	19		19.4	
5	14.1		17.1	.9	16.2		18.9	.0	18.9	.4	18.5		19	
6	14.6		16.7	.8	15.9		18.6	.4	18.2	.1	18.1		18.6	
7	15.9		16.4	.3	16.1		18.7	.6	18.1	.1	18		18.6	
8	15.9		16.9	.7	16.2		19.4	.4	19	.7	18.3		18.6	
9	15.4		17.1	1.2	15.9		19.4	.5	18.9	.9	18.0		18.6	
10	12.5		16.1	1.1	15		19.5	.8	18.7	.3	17.4		18.6	
Average deposit				.57				.32		.05		.28		
Annual rate				.28				.55		.05		.84		

Inner division, section 13.

[May and June, 1887, average depth before dredging, 5.9. Two cuts started Nov., 1887; dredgi pleted 200 feet Apr. to Nov., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		June 9, 1890.	Deposit.	June 12, 1892.	Deposit.	Apr. 17, 1893.		Nov. 29, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.
North 10	15.3	Dredged in May and June, 1890.	16.5	1.3	15.2	1.1	14.1	Dredged in fall, 1895.	20.4	1.2	19.2	0.6	18.6	—.1	18.7	1.
9	15.4		16.7	1.3	15.4	.9	14.5		20.3	.6	19.7	.9	18.8	.4	18.4	.
8	14.5		16.7	1	15.7	.9	14.8		19.7	.1	19.6	.9	18.7	.7	18	.
7	14.1		17	1.1	15.9	.8	15.1		18.8	.3	18.5	.7	17.8	.1	17.7	.
6	14.3		17.4	1.2	16.2	.4	15.8		18.5	.7	17.8	—.1	17.9	.3	17.6	.
5	14.7		17.3	.5	16.8	.6	16.2		18.5	.5	18	—.4	18.4	.6	17.8	.
4	14.1		17.2	.2	17	.2	16.8		19.2	1.1	18.1	—.9	19	.4	18.6	.
3	13.7		17.1	.1	17	.1	16.9		19.4	.6	18.8	—.8	19.6	.5	19.1	.
2	14.2		16.9	—.2	17.1	.2	16.9		19.3	.3	19	—.5	19.5	.1	19.4	.
1	14.3		16.6	—.5	17.1	.3	16.8		19.5	.5	19	—.5	19.5	.2	19.3	.
South 1	14		16.8	—.2	17	.5	16.5		19.2	.3	18.9	—.6	19.5	.3	19.2	
2	13.5		16.8	.0	16.8	1.2	15.6		19.2	.4	18.8	—.6	19.4	.4	19	
3	13.9		17	.3	16.7	1.5	15.2		19.2	.5	18.7	—.3	19	.1	18.9	
4	14.6		17.1	.8	16.3	1.4	14.9		19	.6	18.4	.0	18.4	.2	18.2	
5	14.6		17.1	1.4	15.7	1	14.7		18.5	.5	18	.2	17.8	.4	17.4	
6	15		17.3	2.2	15.1	.9	14.2		17.8	.4	17.4	.4	17	.2	16.8	
7	15.4		17.1	2.2	14.9	1	13.9		18.1	.9	17.2	.4	16.8	.1	16.7	
8	15.7		16.9	2.2	14.7	1	13.7		18.9	.9	18	.5	17.5	.5	17	
9	14.3		16.9	2.3	14.6	1.5	13.1		19.2	.8	18.4	.6	17.8	.5	17.3	
10	11.4		16.8	2.5	14.3	1.7	12.6		19.3	.7	18.6	.9	17.7	.4	17.3	
Average deposit				.98		.86				.60		.07		.32		.28
Annual rate				.49		1.03				1.03		.07		.96		.48

Inner division, section 12.

May and June, 1887, average depth before dredging, 6.1. One cut started Nov., 1887; dredging completed 200 feet June to Oct., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		May 20, 1890.	Deposit.	June, 1892.	Deposit.	Apr. 17, 1893.		Nov. 29, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 26, 1898.
North 10	15.4	Dredged Apr. and May, 1890.	17.2	3.1	14.1	—0.9	15	Dredged in summer, 1895.	19.9	0.8	19.1	1	18.1	0.2	17.9	0.5	17.4
9	15.5		17.4	2.4	15	— .5	15.5		20.3	.7	19.6	1	18.6	.5	18.1	.5	17.6
8	15.3		17	1.7	15.3	— .1	15.4		20	.0	20	1.6	18.4	.4	18	.5	17.5
7	14.3		17.1	1.8	15.3	— .3	15.6		19.1	—.2	19.3	1.8	17.5	—.1	17.6	.5	17.1
6	13.5		17.3	1.9	15.4	— .7	16.1		18.2	.3	17.9	.3	17.6	.2	17.4	.4	17
5	13.6		17.3	1.6	15.7	— .7	16.4		18.2	.3	17.9	.1	18	.5	17.5	.2	17.3
4	13.3		17.3	1.4	15.9	— .7	16.6		18.2	.2	18	.4	18.4	.4	18	.0	18
3	13.4		17	.8	16.2	— .7	16.9		18.6	.3	18.5	.4	18.9	.4	18.5	—.3	18.8
2	14.2		17.1	.6	16.5	— .4	16.9		18.8	—.1	18.7	.5	19.2	.4	18.8	—.3	19.1
1	14.4		16.9	.1	16.8	— .0	16.8		18.9	.0	18.9	.3	19.2	.3	18.9	—.3	19.2
South 1	12.9		16.9	.2	16.7	— .4	16.3		18.9	.1	18.8	.5	19.3	.3	19	—.2	19.2
2	11.6		17.3	1.1	16.2	— .6	15.6		19	.1	18.9	.4	19.3	.3	19	.1	18.9
3	12.3		17.3	1.6	15.7	— .5	15.2		18.7	—.1	18.8	.2	19	.4	18.6	.2	18.4
4	14.2		16.9	1.7	15.2	— .3	14.9		18.5	.0	18.5	.4	18.1	.3	17.8	.1	17.7
5	14.3		16.9	1.9	15	— .5	14.5		18.4	.3	18.1	.7	17.4	.2	17.2	.4	16.8
6	14.5		16.8	2.2	14.6	— .5	14.1		17.4	.2	17.2	.5	16.7	—.1	16.8	.5	16.3
7	15.1		16.9	2.9	14	— .2	13.8		17.7	.0	17.7	1.1	16.6	.0	16.6	.6	16
8	15.4		16.9	3	13.9	— .2	13.7		18.8	.6	18.2	1	17.2	.2	17	.8	16.2
9	15.5		16.4	2.7	13.7	— .4	13.3		19.2	.7	18.5	.9	17.6	.1	17.5	.9	16.6
10	15.7		16.3	3.2	13.1	— .2	12.9		19.2	.6	18.6	.8	17.8	.2	17.6	1.1	16.5
Average deposit.				1.80		— .06				.24		.42		.26		.31	
Annual rate				.86		— .07				.41		.42		.78		.53	

Inner division, section 11.

[May and June, 1887, average depth before dredging, 6.3. Two cuts half way, Oct. and Nov., 1887; dredging completed 200 feet May to Oct., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		May 20, 1890.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Aug. 24, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 26, 1898.
North 10	15	Dredged Oct. and Nov., 1889, and Apr. and May, 1890.	17.3	2.7	14.6	—0.3	14.9	Dredged in summer, 1895.	19.5	0.8	18.7	0.8	17.9	0.3	17.6	0.7	16.9
9	15.3		17.5	2.4	15.1	— .2	15.3		19.2	.3	18.9	.9	18	.3	17.7	.7	17
8	15.1		17.3	2	15.3	— .1	15.4		19	.3	18.7	.7	18	.4	17.6	.6	17
7	14.3		16.9	1.5	15.4	— .0	15.4		18	—.1	18.1	.3	17.8	.3	17.5	.4	17.1
6	13.8		17	1.4	15.6	— .6	16.2		18	.0	18	.0	18	.5	17.5	.3	17.2
5	13.7		17.4	1.4	16	— .8	16.8		18.3	.3	18	.0	18	.5	17.5	.0	17.5
4	13.6		17.5	1	16.5	— .6	17.1		18.6	.4	18.2	—.1	18.3	.4	17.9	—.1	18
3	12.5		17.1	.3	16.8	— .3	17.1		18.8	.1	18.7	.0	18.7	.3	18.4	—.2	18.6
2	14		16.8	.3	16.5	— .9	17.4		18.9	—.1	19	.1	18.9	.0	18.9	.1	18.8
1	14.3		16.7	.3	16.4	—1.1	17.5		19	.0	19	.1	18.9	—.1	19	.0	19
South 1	13.5		16.9	.9	16	— .8	16.8		18.6	—.1	18.7	—.2	18.9	—.2	19.1	.1	19
2	12.8		17.2	1.4	15.8	— .3	16.1		18.5	—.2	18.7	—.1	18.8	—.2	19	.3	18.7
3	13.6		17.1	1.6	15.5	— .1	15.6		18.2	—.4	18.6	.0	18.6	.0	18.6	.6	18
4	14.9		16.9	1.9	15	— .4	15.4		17.9	.1	17.8	—.4	18.2	.0	18.2	.7	17.5
5	14.4		16.8	2.3	14.5	— .5	15		18	.3	17.7	.3	17.4	—.2	17.6	.6	17
6	14.5		16.8	2.5	14.3	— .3	14.6		18	.6	17.4	.4	17	.0	17	.1	16.9
7	15.2		16.8	2.8	14	— .5	14.5		19.4	1.3	18.1	.7	17.4	.1	17.3	.3	17
8	15.1		16.6	2.7	13.9	— .4	14.3		19.9	.7	19.2	1.1	18.1	.3	17.8	.5	17.3
9	15.3		16.1	2.6	13.5	— .2	13.7		20	.6	19.4	1.3	18.1	.2	17.9	.6	17.3
10	15.7		15.2	2.3	12.9	— .2	13.1		19.6	.2	19.4	1.2	18.2	.4	17.8	.7	17.1
Average deposit.				1.72		—.43				.26		.36		.16		.35	
Annual rate				.82		—.43				.31		.36		.48		.60	

Inner division, section 10.

[May and June, 1887, average depth before dredging, 6.6. Two cuts, Oct. and Nov., 1887; dredging completed 200 feet May to Oct., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		May 20, 1890.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Aug. 24, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 26, 1898.
North 10	15	Dredged in Oct. and Nov., 1889, and Apr. and May, 1890.	16.5	1.8	14.7	0.5	14.2	Dredged in summer, 1895.	19.9	1	18.9	0.9	18	0.2	17.8	1	16.8
9	15.1		16.7	1.8	14.9	.2	14.7		19.9	.9	19	.8	18.2	.2	18	1	17
8	14.8		17.3	2.3	15	.1	14.9		20	1.2	18.8	.5	18.3	.4	17.9	.9	17
7	14.3		17.5	1.8	15.7	.2	15.5		18.7	.5	18.2	.1	18.1	.4	17.7	.9	16.8
6	13.9		17.6	1.5	16.1	.4	15.7		18	.2	17.8	.1	17.7	.0	17.7	.7	17
5	13.9		17.5	1.3	16.2	.1	16.3		18.2	.9	18.3	.5	17.8	.0	17.8	.5	17.3
4	14.5		17.5	1.3	16.2	.6	16.8		18.6	.1	18.5	.3	18.2	.2	18	.2	17.8
3	14.2		17	.7	16.3	.8	17.1		18.9	.2	18.7	.3	18.4	.1	18.5	.3	18.1
2	14.5		16.7	.3	16.4	.8	17.2		18.8	.2	18.5	.3	18.8	.0	18.8	.3	18.4
1	13.8		16.6	.1	16.5	.7	17.2		18.9	.3	18.6	.4	19	.0	19	.2	18.6
South 1	13		16.9	.6	16.3	.9	17.2		18.8	.3	18.5	.6	19.1	.0	19.1	.2	18.8
2	12.4		16.7	.6	16.1	.9	17		18.9	.4	18.5	.4	18.9	.2	19.1	.3	18.5
3	13.1		16.8	1.1	15.7	.9	16.6		18.7	.2	18.5	.3	18.8	.3	19.1	.9	18.2
4	14.4		17	1.6	15.4	.6	16		18.5	.3	18.2	.2	18.4	.4	18.8	1.3	17.8
5	14.4		16.9	1.8	15.1	.3	15.4		18.5	.7	17.8	.1	17.9	.4	18.3	1.2	17.1
6	14.6		16.8	2.2	14.6	.4	15		17.9	.3	17.6	.2	17.4	.5	17.9	1.1	16.8
7	15		16.7	2.4	14.3	.2	14.5		18.5	.7	17.8	.4	17.4	.0	17.4	.7	16.7
8	15.4		16.7	2.4	14.3	.0	14.3		19	.1	18	.3	17.7	.4	17.3	.7	16.6
9	16		16.5	2.4	14.1	.1	14		18.2	.0	18.2	.4	17.8	.3	17.5	1	16.5
10	15.8		16.1	2.5	13.6	.0	13.6		19.1	.8	18.3	.5	17.8	.5	17.3	.9	16.4
Average deposit				1.52		.28				.47		.15		.04		.72	
Annual rate				.73		.28				.56		.15		.12		1.23	

Inner division, section 9.

[May and June, 1887, average depth before dredging, 6.9. Two cuts, Oct., 1887; dredging completed 200 feet June to Sept., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		Nov. 11, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Aug. 24, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
North 10	15.5	Dredged Oct. and Nov., 1888.	17	2.6	14.4	0.7	13.7	Dredged in summer, 1895.	19.6	1.1	18.5	0.9	17.6	0.3	17.3	1	16.3
9	15.5		17.1	2.3	14.8	.3	14		19.8	.9	18.9	1.1	17.8	.4	17.4	.8	16.6
8	14.7		17.3	2.3	15	.4	14.6		19.7	.9	18.8	1.2	17.6	.3	17.3	.7	16.6
7	13.5		17.5	2.2	15.3	.3	15		18.7	.3	18.4	1	17.4	.1	17.3	.7	16.6
6	13.2		17.6	2.1	15.5	.0	15.5		18.3	.3	18	.7	17.3	.1	17.4	.6	16.8
5	13.9		17.5	1.7	15.8	.1	15.9		18.5	.5	18	.4	17.6	.1	17.7	.4	17.3
4	13.6		17.5	1.4	16.1	.3	16.4		18.8	.4	18.4	.4	18	.3	18.3	.5	17.8
3	13.2		17.4	1	16.4	.5	16.9		18.3	.2	18.6	.1	18.5	.1	18.6	.5	18.1
2	13.7		17.1	.6	16.5	.5	17		18.9	.3	18.6	.0	18.6	.1	18.7	.3	18.4
1	13.6		17	.3	16.7	.3	17		18.3	.3	18.5	.2	18.7	.1	18.8	.2	18.6
South 1	13		16.9	.3	16.6	.3	16.9		18.6	.1	18.5	.3	18.8	.1	18.9	.2	18.7
2	12.4		16.8	.6	16.2	.6	16.8		18.6	.2	18.4	.3	18.7	.0	18.7	.1	18.6
3	12.8		16.7	.6	16.1	.1	16		18.5	.3	18.2	.2	18.4	.0	18.4	.3	18.1
4	13.9		17	1.3	15.7	.0	15.7		18	.0	18	.0	18	.1	17.9	.2	17.1
5	13.7		17.1	1.7	15.4	.5	14.9		17.6	.1	17.7	.2	17.5	.0	17.5	.4	17.1
6	13.3		17.2	2.4	14.8	.4	14.4		17.7	.3	17.4	.1	17.3	.1	17.4	.6	16.8
7	14.1		17.1	2.5	14.6	.5	14.1		18.8	1.5	17.3	.2	17.5	.1	17.4	.5	16.9
8	15.7		17.3	2.7	14.6	.5	14.1		19.7	1.3	18.4	.6	17.8	.1	17.7	.7	17
9	16.1		16.8	2.3	14.5	.6	13.9		19.6	.9	18.7	.8	17.9	.1	17.8	.8	17
10	16		16.4	2.4	14	.7	13.3		19.5	.9	18.6	.9	17.7	.2	17.5	.8	16.8
Average deposit				1.66		.14				.53		.36		.04		.52	
Annual rate				.64		.14				.64		.36		.12		.89	

Inner division, section 8.

y and June, 1887, average depth before dredging, 6.7. Two cuts, Sept. and Oct., 1887; dredging completed 200 feet June to Sept., 1888.]

ot inter-ls from axis.	Nov. 18, 1888.		Oct. 20, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Aug. 24, 1895.	Deposit.	June 17, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
th 10....	15.9	Dredged in July, Sept., and Oct., 1889.	17	2.5	14.5	0.7	13.8	Dredged in spring, 1895.	20.4	1.7	18.7	0.9	17.8	0.2	17.6	0.6	17
9....	16		17.3	2.3	15	1	14		20.5	1.1	19.4	1.5	17.9	.2	17.7	.6	17.1
8....	14.8		17.4	2	15.4	1.2	14.2		20.4	1	19.4	1.5	17.9	.2	17.7	.6	17.1
7....	14		17.2	1.7	15.5	1.1	14.4		19	.4	18.6	1.1	17.5	.2	17.3	.3	17
6....	13.8		17.4	1.7	15.7	.7	15		18.3	.5	17.8	.8	17	.2	17.2	.2	17
5....	14.2		17.5	1.6	15.9	.3	15.6		18.5	.5	18	.4	17.6	.0	17.6	.1	17.5
4....	13.7		17.4	1.2	16.2	.3	15.9		18.7	.4	18.3	.3	18	.1	18.1	.1	18
3....	13.3		17.4	1	16.4	.0	16.4		18.8	.2	18.6	.0	18.6	.1	18.7	.4	18.3
2....	13.6		17.2	.7	16.5	.1	16.6		19.2	.4	18.8	.0	18.8	.2	19	.2	18.8
1....	13.4		17.1	.4	16.7	.0	16.7		19	.1	18.9	.1	19	.0	19	.0	19
th 1....	12.6		16.6	.0	16.6	.0	16.6		18.8	.0	18.8	.3	19.1	.0	19.1	.3	18.8
2....	12.1		16.2	.0	16.3	.0	16.3		19	.2	18.8	.1	18.9	.0	18.9	.1	18.8
3....	12.5		16.7	.7	16	.3	15.7		18.9	.3	18.7	.0	18.7	.2	18.5	.1	18.4
4....	13.9		16.7	1	15.7	.6	15.1		18.9	.3	18.6	.2	18.4	.1	18.3	.4	17.9
5....	13.5		16.8	1.7	15.1	.4	14.7		18.8	.5	18.3	.5	17.8	.1	17.9	.6	17.3
6....	13.5		16.7	2	14.7	.4	14.3		18.2	.5	18.7	.5	17.2	.2	17.4	.7	16.7
7....	14.5		16.5	2	14.5	.5	14		18.5	.9	17.6	.4	17.2	.0	17.2	.4	16.8
8....	15.3		16.6	2.3	14.3	.7	13.6		19.8	1	18.8	.8	18	.2	17.8	.6	17.2
9....	16		16.3	2.2	14.1	.7	13.4		20.1	1.1	19	.8	18.2	.2	18	.7	17.3
10....	16.3		16	2	14	.8	13.2		20	.8	19.2	1.1	18.1	.1	18	.8	17.2
Average deposit				1.45		.48				.59		.52		.04		.39	
Annual rate				.54		.48				.71		.52		.12		.67	

Inner division, section 7.

y and June, 1887, average depth before dredging, 7.3. Two cuts, Sept., 1887; dredging completed 200 feet June to Sept., 1888.]

et inter-ls from axis.	Nov. 18, 1888.		Aug. 29, 30, Sept. 23, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Aug. 24, 1896.	Deposit.	June 16, 1896.	Deposit.	June, 1897.	Deposit.	Oct. 1897.	Deposit.	May 24, 1898.
th 10....	15.7	Dredged June and July, 1889.	16.2	2.1	14.1	1	13.1	Partly dredged in fall, 1894; completed in spring, 1895.	19.7	0.4	19.3	1.1	18.2	0.4	17.8	1.1	16.7
9....	16.2		16.7	2.1	14.6	1	13.6		20.1	.5	19.6	1.3	18.3	.3	18	.9	17.1
8....	15.4		16.5	1.7	14.8	.9	13.9		20	1	19	.9	18.1	.4	17.7	.5	17.2
7....	13.9		16.5	.9	15.6	1.3	14.3		18.8	.8	18	.4	17.6	.2	17.4	.3	16.6
6....	13.3		16.7	1.6	15.1	.4	14.7		18	.1	17.9	.6	17.3	.0	17.3	.7	16.6
5....	13.6		16.5	1	15.5	.3	15.2		18	.2	18.2	.8	17.4	.2	17.6	.6	17
4....	13.6		15.8	.0	15.8	.0	15.8		18.3	.0	18.3	.4	17.9	.1	18	.4	17.6
3....	13.3		16.2	.1	16.1	.3	16.3		18.9	.3	18.6	.2	18.4	.0	18.4	.3	18.1
2....	13.9		16.5	.2	16.3	.3	16.6		19.1	.1	19	.3	18.7	.1	18.6	.2	18.4
1....	13.9		16.3	.2	16.5	.1	16.6		19.1	.0	19.1	.2	18.9	.1	18.8	.0	18.8
th 1....	13		16.3	.2	16.5	.2	16.3		18.9	.1	19	.0	19	.0	19	.2	18.8
2....	12.6		16.3	.0	16.3	.6	16.7		18.7	.1	18.8	.1	18.9	.1	19	.4	18.6
3....	13.1		15.8	.3	16.1	.8	15.3		18.5	.2	18.7	.5	18.2	.5	18.7	.7	18
4....	13.8		15.9	.2	15.7	.8	14.9		18.3	.1	18.4	.6	17.8	.5	18.3	1	17.3
5....	13.3		16.4	1.2	15.2	.8	14.4		18	.1	17.9	.6	17.3	.4	17.7	.9	16.8
6....	13.3		16.3	1.5	14.8	1	13.8		18.1	.7	17.4	.2	17.2	.1	17.3	.7	16.6
7....	14.6		16.3	1.7	14.6	1.3	13.3		18.6	.5	18.1	.1	18.2	.8	17.4	.5	16.9
8....	15.7		16.1	1.7	14.4	1.4	13		19.6	.4	19.2	.7	18.5	.8	17.7	.3	17.4
9....	16.4		15.5	1.6	13.9	1.4	12.5		19.9	.5	19.4	.7	18.7	.7	18	.6	17.4
10....	16.3		15.2	1.7	13.5	1.1	12.4		19.6	.3	19.3	.9	18.4	.3	18.1	1	17.1
Average deposit				.93		.68				.25		.51		.11		.59	
Annual rate				.33		.68				.30		.51		.33		1.01	

Inner division, section 6.

[May and June, 1887, average depth before dredging, 7.1. Two cuts, Aug. and Sept., 1887; di completed 200 feet June to Sept., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		Sept. 23 and 24, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Dec. 3, 1894.	Deposit.	June 16, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.
North 10....	15	Dredged in June, July, and Sept., 1889.	16.8	2.5	14.3	0.7	13.6	Dredged in fall, 1894.	18.4	0.8	17.6	1.7	15.9	—1.1	17	1.
9....	16.3		17.4	2.4	15	1	14		19.6	.8	18.8	1.1	17.7	.1	17.6	.
8....	15.2		17.2	2.1	15.1	.9	14.2		20.1	.9	19.2	1	18.2	.5	17.7	.
7....	14.2		17.2	2.1	15.1	.6	14.5		20.3	.7	19.6	1.3	18.3	.3	18	.
6....	13.7		17.1	1.9	15.2	.4	14.8		19.7	.0	19.7	1.4	18.3	.3	18	.
5....	13.9		17.1	1.7	15.4	.1	15.5		18.5	.1	18.4	.1	18.3	.6	17.7	.
4....	13.3		17.1	1.4	15.7	.3	16		18.1	.1	18	.2	18.2	.4	17.8	.
3....	12.8		17.1	1.1	16	.3	16.3		18.3	.4	17.9	.2	18.1	.1	18	.
2....	13.7		16.7	.5	16.2	.3	16.5		17.5	—.5	18	.2	18.2	.2	18	.
1....	14.6		16.5	.1	16.4	.2	16.6		16.9	—.5	17.4	.8	18.2	.1	18.1	.
South 1....	14.4		16.6	.1	16.5	.0	16.5		16.9	—1.0	17.9	.3	18.2	.1	18.1	.
2....	13.7		16.2	.3	16.5	.4	16.1		17.4	—.6	18	.3	18.3	.1	18.2	.
3....	13.6		16.4	.3	16.1	.6	15.5		17.8	—.2	18	.4	18.4	.2	18.2	.
4....	14.3		16.7	1	15.7	.8	14.9		18.2	.3	17.9	.3	18.2	.1	18.1	.
5....	13.5		16.3	1.1	15.2	.8	14.4		18.8	—.1	18.9	.5	18.4	.3	18.1	.
6....	13.6		16	1.3	14.7	.9	13.8		20	.3	19.7	1	18.7	.3	18.4	.
7....	14.7		16.1	1.6	14.5	1	13.5		20.2	.6	19.6	1	18.6	.4	18.2	.
8....	16		15.9	1.5	14.4	1	13.4		19.9	.7	19.2	.9	18.3	.1	18.2	.
9....	16.4		15.9	1.6	14.3	1	13.3		19	.2	18.8	.8	18	.2	17.8	.
10....	16.1		16.1	2	14.1	.9	13.2		17.1	—.6	17.7	.1	17.6	.5	17.1	.
Average deposit.	.....	.....	.....	1.30	.....	.49	.....	.....	.....	.12	.....	.41	.....	.19	.....	.
Annual rate....	.....	.....	.....	.47	.....	.49	.....	.....	.....	.08	.....	.41	.....	.57	.....	.

Inner division, section 5.

[May and June, 1887, average depth before dredging, 7.5. Two cuts, Aug. and Sept., 1887; di completed 200 feet May to Oct., 1888.]

10-foot intervals from axis.	Nov. 13, 1888.		May 20, 1890.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Dec. 3, 1894.	Deposit.	June 16, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.
North 10..	15.8	Dredged in Oct. and Nov., 1889, April and May, 1890.	17.3	2.4	14.9	1.4	13.5	Dredged in fall, 1894.	18.1	1.4	16.7	1.2	15.5	—1.1	16.6	1.
9..	16		17	1.8	15.2	1.1	14.1		19.4	1	18.4	1	17.4	—.1	17.5	.
8..	15.3		16.9	1.7	15.2	1.0	14.2		20.1	1.2	18.9	1.2	17.7	.0	17.7	.
7..	14.6		17	1.6	15.4	1.1	14.3		20	.8	19.2	1.2	18	.2	17.8	.
6..	13.9		17.1	1.6	15.5	.8	14.7		19.8	.5	19.3	1.1	18.2	.3	17.9	.
5..	13.9		17.1	1.3	15.7	.6	15.1		18.3	—.5	18.8	.7	18.1	.3	17.8	.
4..	14.1		17	.9	16.1	.4	15.7		18.2	.1	18.1	.0	18.1	.0	18.1	.
3..	14		17	.6	16.4	.3	16.1		18.1	.0	18.1	.2	18.3	.1	18.2	.
2..	15.2		16.9	.5	16.4	.2	16.6		17.5	—.4	17.9	.3	18.2	.2	18	.
1..	15.6		16.7	.3	16.4	.4	16.8		16.7	—.8	17.5	.7	18.2	.3	17.9	.
South 1..	15.1		16.8	.3	16.5	.0	16.5		17	—.5	17.5	.8	18.3	.3	18	.
2..	13.8		16.8	.3	16.5	.4	16.1		17.7	.0	17.7	.6	18.3	.1	18.2	.
3..	13.5		16.9	.5	16.4	.7	15.7		18	.2	17.8	.6	18.4	.1	18.3	.
4..	13.9		16.8	.7	16.1	1	15.1		17.6	—.2	17.8	.4	18.2	.1	18.1	.
5..	13.9		16.7	.9	15.8	1.1	14.7		19	.5	18.5	.0	18.5	.3	18.2	.
6..	14		16.8	1.5	15.3	.9	14.4		20	.5	19.5	.9	18.6	.2	18.4	.
7..	14.9		16.7	1.5	15.2	1.2	14		20.2	1.2	19	.5	18.5	.2	18.3	.
8..	15.9		16.5	1.8	14.7	.9	13.8		19.9	1.6	18.3	—.1	18.4	.7	17.7	.
9..	16.1		16.5	2.2	14.3	.6	13.7		19.2	1.2	18	.0	18	.6	17.4	.
10..	16		16.4	2	14.4	.7	13.7		17.6	1	16.6	.6	16	—.4	16.4	.
Average deposit.	.....	.....	.....	1.22	.....	.68	.....	.....	.....	.44	.....	.24	.....	.12	.....	.
Annual rate....	.....	.....	.....	.59	.....	.68	.....	.....	.....	.29	.....	.24	.....	.36	.....	.

Inner division, section 4.

[May and June, 1887, average depth before dredging, 7.8. Two cuts, Aug., 1887; dredging completed 200 feet May to September, 1888.]

10-foot intervals from axis.	Nov. 18, 1888.		Oct. 30, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Dec. 8, 1894.	Deposit.	June 16, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
North 10	15.2	Dredged in July, Sept., and Oct., 1888.	17.3	2.8	14.5	1.2	13.3	Dredged in fall, 1894.	17.3	1.2	16.1	—0.3	16.4	—0.1	16.5	1	15.5
9	15.7		17.4	2.3	15.1	1	14.1		19.3	1.4	17.9	.3	17.6	.2	17.4	1.2	16.2
8	15.3		17.2	2.2	15	.7	14.3		19.8	1.4	18.4	.4	18	.3	17.7	.9	16.8
7	14.5		17.1	2	15.1	.5	14.6		20.1	1.5	18.6	.5	18.1	.3	17.8	.6	17.2
6	13.9		17.2	1.8	15.4	.3	15.1		20.3	1.1	19.2	1	18.2	.4	17.8	.3	17.5
5	14		16.9	1.3	15.6	.2	15.4		19		19.2	.9	18.3	.4	17.9	.3	17.6
4	13.3		16.8	1.1	15.7	.1	15.8		17.5	.3	17.8	.4	18.2	.1	18.1	.4	17.7
3	13.7		16.9	.9	16	.3	16.3		17.9	.4	17.5	.7	18.2	.0	18.2	.2	18
2	15.6		16.9	.6	16.3	.4	16.7		17.9	.0	17.9	.3	18.2	.1	18.3	.1	18.4
1	17.1		17.1	.6	16.5	.2	16.7		17	.8	17.8	.4	18.2	.1	18.3	.1	18.2
South 1	17.3		17.1	.5	16.6	.1	16.7		16.9	.9	17.8	.4	18.2	.1	18.3	.1	18.2
2	15.9		16.9	.4	16.5	.1	16.4		17.5	.5	18	.3	18.3	.1	18.2	.0	18.2
3	14		17	.7	16.3	.3	16		17.9	.2	17.7	.6	18.3	.1	18.2	.1	18.1
4	12.7		17.2	1.2	16	.6	15.4		17.3	.3	17.6	.8	18.4	.3	18.1	.3	17.8
5	12.5		17.1	1.4	15.7	.8	14.9		18	.1	18.1	.2	17.9	.0	17.9	.3	17.6
6	12.7		16.6	1.3	15.3	1.1	14.2		19.2	.6	18.6	.5	18.1	.1	18	.5	17.5
7	14.9		16.4	1.8	14.6	.9	13.7		19.7	.9	18.8	.6	18.2	.2	18	.7	17.3
8	16.2		16.4	2.1	14.3	.7	13.6		19.5	.9	18.6	.5	18.1	.3	17.8	.8	17
9	16.6		16.3	2.1	14.2	.7	13.5		19.2	.6	18.6	.8	17.8	.2	17.6	.7	16.9
10	16.5		15.9	2	13.9	.7	13.2		18.4	.6	17.8	—.1	17.9	.9	17	.5	16.5
Average deposit				1.46		.44				.38		.07		.18		.44	
Annual rate				.55		.44				.25		.07		.54		.75	

Inner division, section 3.

[May and June, 1887, average depth before dredging, 7.8. Two cuts, Aug., 1887; dredging completed 200 feet June to Aug., 1888.]

10-foot intervals from axis.	Nov. 18, 1888.		Nov. 11, 1889.	Deposit.	June, 1892.	Deposit.	June 24, 1893.		Dec. 8, 1894.	Deposit.	June 16, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
North 10	14.9	Dredged in June, Sept., and Oct., 1889.	17.6	2.8	14.8	1.2	13.6	Dredged in fall, 1894.	18.6	1.6	17	0.3	16.7	0.2	16.5	0.9	15.6
9	15.2		17.7	2.8	14.9	.8	14.1		19.6	1.1	18.5	1.1	17.4	.3	17.1	.9	16.2
8	14.9		17.4	2.5	14.9	.8	14.1		19.5	1.2	18.3	.9	17.4	.2	17.2	.8	16.4
7	14.2		17.3	2.2	15.1	.7	14.4		18.9	.6	18.3	.9	17.4	.1	17.3	.6	16.7
6	14		17.3	2	15.2	.5	14.8		18.4	.5	17.9	.3	17.6	.0	17.6	.7	16.9
5	12.7		17.3	1.8	15.5	.3	15.2		18.7	.7	18	.1	17.9	.0	17.9	.7	17.2
4	12.5		17.3	1.4	15.9	.2	15.7		18.7	.5	18.2	.0	18.2	.1	18.1	.4	17.7
3	13.1		17.5	1.2	16.3	.2	16.1		18.8	.3	18.1	—.1	18.2	.0	18.2	.3	17.9
2	15.2		17.4	.9	16.5	.2	16.7		17.1	.5	17.6	—.5	18.1	.1	18.2	.2	18
1	16.8		17.2	.7	16.5	.4	16.9		16.9	.6	17.5	—.6	18.1	.1	18.2	.1	18.1
South 1	16.9		17	.5	16.5	.3	16.8		17	.7	17.7	—.5	18.2	.0	18.2	—.1	18.3
2	15.9		17.1	.7	16.4	.2	16.6		17.4	.7	18.1	—.3	18.4	.1	18.3	—.2	18.5
3	13.8		17.7	1.6	16.1	.0	16.1		18.4	.0	18.4	.0	18.4	.1	18.5	.1	18.4
4	13.2		17.7	1.9	15.8	.3	15.5		18.6	.2	18.4	.0	18.4	.1	18.5	.4	18.1
5	12.4		17.5	2.1	15.4	.5	14.9		18.6	.5	18.1	—.1	18.2	.0	18.2	.4	17.8
6	12.6		17.3	2.3	15	.4	14.6		18.3	.4	17.9	—.1	18	.2	17.8	.3	17.5
7	14.5		17.1	2.3	14.8	.6	14.2		18.8	.8	18	—.2	18.2	.6	17.6	.4	17.2
8	15.5		17.1	2.6	14.5	.8	13.7		19.4	1	18.4	.2	18.2	.4	17.8	.6	17.2
9	16.1		17.1	3	14.1	1	13.1		19.5	1.2	18.3	.5	17.8	.1	17.7	.7	17
10	16		16.7	2.8	13.9	.9	13		18.7	1.2	17.5	.5	17	—.2	17.2	.7	16.5
Average deposit				1.90		.40				.46		.12		.08		.44	
Annual rate				.74		.40				.30		.12		.24		.75	

Middle division, section 13.

[Part of old channel. First dredged as part of straight channel in May and June, 1890.]

10-foot intervals from axis.	Oct. and Nov., 1887.		June 23, 1890.		June 24, 1891.	Deposit.	June, 1892.	Deposit.	June 23, 1893.		Sept. 29, 1894.	Deposit.	June 13, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 21 1898
North 10.	8.8	Dredged, May and June, 1890.	16.4	....	16.2	2	14.2	—0.4	14.6	Dredged in summer, 1894.	18	0.7	17.3	0.2	17.1	—0.3	17.4	1.5	15.
9.	9.3		16.7	....	16.5	1.8	14.7	— .1	14.8		19.2	1.2	18	.5	17.5	— .1	17.6	1.2	16.
8.	9.8		16.8	....	16.7	1.7	15	.0	15		19.6	1.4	18.2	.7	17.5	— .2	17.7	.9	16.
7.	10.2		16.7	....	16.7	1.3	15.4	.1	15.3		19.7	1.2	18.5	.7	17.8	.0	17.8	.6	17.
6.	10.7		16.9	....	16.7	1.2	15.5	— .1	15.6		20	.9	19.1	1.2	17.9	.1	17.8	.5	17.
5.	11.4		17.3	....	17	1.2	15.8	— .6	16.4		18.8	.5	18.3	.6	17.7	— .2	17.9	.6	17.
4.	12.5		17.5	....	17.5	1.3	16.2	— .7	16.9		17.6	.5	18.1	.3	17.8	— .3	18.1	.5	17.
3.	13.4		17.1	....	17.8	1.2	16.6	— .4	17		18	.0	18	.1	17.9	— .3	18.2	.4	17.
2.	13.8	.....	16	Dredged in May, 1891.	17.6	.6	17	.0	17		17.8	.0	17.8	.2	18	— .2	18.2	.3	17.
1.	14.2	.....	15		17.5	.4	17.1	— .1	17.2		17.2	.3	17.5	.5	18	— .2	18.2	.2	18
South 1	14.9	.....	14.9		17.5	.3	17.2	— .1	17.3		17.4	.2	17.6	.5	18.1	— .1	18.2	.2	18
2.	15.1	.....	15.5		17.2	.1	17.1	— .1	17.2		17.4	.2	17.6	.6	18.2	— .1	18.3	.2	18.
3.	15.6	.....	16.1		17	.1	17.1	.1	17		18	.3	18.3	.1	18.4	.1	18.3	.2	18.
4.	15.5	.....	16.4		17.2	.2	17	.3	16.7		18.2	.0	18.2	.2	18	.0	18	.0	18
5.	15.3	.....	16.5		17.2	.5	16.7	.4	16.3		17.6	.2	17.8	.1	17.9	— .2	18.1	.2	17.
6.	15.0	.....	16.4		17.3	.8	16.5	.5	16		18.8	.3	18.5	.4	18.1	.0	18.1	.4	17.
7.	14.9	.....	16.1		17.4	1.1	16.3	.5	15.8		19.2	.9	19	1	18	.0	18	.4	17.
8.	14.5	.....	15.6		17.4	1.4	16	.4	15.6		20	1.2	18.8	.9	17.9	.0	17.9	.5	17.
9.	14.1	.....	15		17.4	1.5	15.9	.5	15.4		19.7	1.1	18.6	.7	17.9	.0	17.9	.6	17.
10.	13.3	.....	14.5		17.1	1.4	15.7	— .2	15.9		19.4	1	18.4	.7	17.7	.0	17.7	.7	17
Average deposit	....	.....	....	....	....	1	....	.00	....	....	....	.44	....	.31	....	— .10	....	.51	...
Annual rate	....	.....	....	....	....	1	....	.00	....	....	....	.25	....	.31	....	— .30	....	.87	...

Middle division, section 12.

[Part of old channel. First dredged as part of straight channel in May and June, 1890.]

10-foot intervals from axis.	Oct. and Nov., 1887.		June 23, 1890.		June 24, 1891.	Deposit.	June, 1892.	Deposit.	June 23, 1893.		Sept. 29, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 21 1898
North 10...	9.2	Dredged, May and June, 1890.	16.2	....	15.3	1.1	14.2	0.0	14.2	Dredged in summer, 1894.	18.4	0.2	18.2	1.2	17	—0.3	17.3	0.9	16.
9...	9.1		16.6	....	16	1.4	14.6	.1	14.5		19.5	1.1	18.4	.8	17.6	— .1	17.7	1.0	16.
8...	9.3		16.2	....	16.2	1.3	14.9	— .2	15.1		19.7	1.1	18.6	.8	17.8	.1	17.7	.8	16.
7...	9.9		16.3	....	16.4	1.3	15.1	— .2	15.3		19.7	.7	19	1.1	17.9	— .1	18	.9	17.
6...	10.6		16.5	....	16.3	.8	15.5	— .1	15.6		20.3	1.1	19.2	1.4	17.8	— .3	18.1	.9	17.
5...	11.6		17	....	16.7	.7	16	.0	16		18.9	.3	18.6	1	17.6	— .4	18	.8	17.
4...	12.6		17	....	16.9	.4	16.5	.1	16.4		17.8	— .2	18	.2	17.8	— .3	18.1	.6	17.
3...	13.1		15.9	....	16.9	.2	16.7	.0	16.7		17.8	— .1	17.9	.1	17.8	— .3	18.1	.2	17.
2...	13.5	.....	15		17	.1	16.9	— .1	17		17.5	.1	17.4	— .3	17.7	— .4	18.1	.1	18
1...	14.3	.....	14.5	Dredged in May, 1891.	17.1	.1	17	— .1	17.1		17	— .5	17.5	— .2	17.7	— .3	18	.1	17.
South 1...	14.7	.....	15.2		17.2	.0	17.2	.0	17.2		17.1	— .5	17.6	— .2	17.8	— .3	18.1	.2	17.
2...	15	.....	15.9		17.5	.4	17.1	— .2	17.3		17.4	— .7	18.1	.0	18.1	— .2	18.3	.2	18.
3...	15.3	.....	16.1		17.5	.5	17	— .2	17.2		17.8	— .6	18.4	.2	18.2	— .1	18.3	.1	18.
4...	15.2	.....	16.2		17.4	.5	16.9	— .1	17		18.2	— .4	18.6	.6	18	— .3	18.3	.3	18
5...	15.3	.....	16.1		17.3	.5	16.8	.1	16.7		18.4	— .2	18.6	.7	17.9	— .4	18.3	.5	17.
6...	15.1	.....	15.7		17.2	.6	16.6	.3	16.3		19.3	— .1	19.4	1.3	18.1	— .2	18.3	.6	17.
7...	14.8	.....	15.2		17.4	1	16.4	.4	16		20.2	1	19.2	1.2	18	— .2	18.2	.7	17
8...	13.8	.....	14.7		17.5	1.5	16	.2	15.8		20.4	1.3	19.1	1.2	17.9	.0	17.9	.5	17
9...	13.4	.....	14.3		17.2	1.4	15.8	.3	15.5		20.2	1.2	19	1.2	17.8	.1	17.7	.4	17
10...	13.0	.....	13.9		17	1.2	15.8	.4	15.4		19.5	.8	18.7	1.4	17.3	.2	17.1	.4	16
Average deposit	....	.....	....	....	....	.75	....	.04	....	....	....	.28	....	.68	....	— .19	....	.51	...
Annual rate	....	.....	....	....	....	.75	....	.04	....	....	....	.16	....	.68	....	— .57	....	.87	...

Middle division, section 15.

[Part of old channel. First dredged as part of straight channel in Sept., 1889.]

Foot intervals from axis.	Oct. and Nov., 1887.		June 5, 1890.	Deposit.	June, 1892.		June 13, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
10th 10	14.9	Dredged in September, 1889.	17.4	2	15.4	Dredged in summer, 1894.	17.9	1.1	16.8	—0.4	17.2	0.5	16.7
9	15		17.6	1.8	15.8		18.8	1	17.8	.2	17.6	.5	17.1
8	15		17.3	1.2	16.1		19	1	18	.1	17.9	.6	17.3
7	14.9		17.5	1.4	16.1		19.4	1.1	18.3	.2	18.1	.7	17.4
6	15		17.6	1.4	16.2		19.8	1.3	18.5	.4	18.1	.4	17.7
5	15		17.4	1.1	16.3		19.1	.8	18.3	.2	18.1	.4	17.7
4	15		17.2	.6	16.6		18	.0	18	.3	18.3	.2	18.1
3	15		17.1	.2	16.9		18	.2	18.2	.2	18.4	.2	18.2
2	15.2		17	.1	17.1		17.7	.7	18.4	.1	18.3	.2	18.1
1	15.1		17	.1	17.1		17.6	.6	18.2	.2	18.4	.3	18.1
1th 1	14.7		16.8	.3	17.1		17.6	.4	18	.4	18.4	.2	18.2
2	14.5		16.6	.4	17		18	.1	18.1	.3	18.4	.1	18.3
3	14.5		16.5	.3	16.8		18.2	.1	18.3	.1	18.4	.2	18.2
4	14.4		16.5	.1	16.6		18	.3	18.3	.2	18.1	.2	17.9
5	14.4		16.5	.4	16.1		18.2	.3	17.9	.0	17.9	.3	17.6
6	14.4		16.3	.6	15.7		18.8	.9	17.9	.0	17.9	.8	17.1
7	14.5		15.7	.6	15.1		18.7	.9	17.8	.2	17.6	.7	16.9
8	14.2		15.6	.8	14.8		18.4	.9	17.5	.4	17.1	.7	16.4
9	13.4		16.5	1.9	14.6		17.9	.6	17.3	.5	16.8	.8	16
10	12.6		16.8	2.2	14.6		17.2	.2	17	.7	16.3	1	15.3
Average deposit				.74				.38		.06		.45	
Annual rate				.87				.88		.18		.77	

Middle division, section 14.

[Part of old channel. First dredged as part of straight channel in Apr. and May, 1890.]

Foot intervals from axis.	Oct. and Nov., 1887.		June 5, 1890.	Deposit.	June, 1892.	Deposit.	June, 1893.		Oct. 1, 1894.	Deposit.	June 13, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 24, 1898.
10th 10	10.9	Dredged, April and May, 1890.	16.7	2.2	14.5	0.0	14.5	Dredged in summer, 1894.	18	0.4	17.6	0.6	17	—0.3	17.3	1.1	16.2
9	11.6		16.8	1.7	15.1	.3	14.8		19.9	1.3	18.6	1	17.6	.1	17.5	.9	16.6
8	12.7		16.9	1.5	15.4	.4	15		20.3	1.6	18.7	.8	17.9	.1	17.8	.9	16.9
7	14		17	1.5	15.5	.3	15.2		20.8	1.7	19.1	1	18.1	.1	18	.8	17.2
6	14.4		17	1.2	15.8	.3	15.5		20.4	1	19.4	1.3	18.1	.1	18	.6	17.4
5	15		17.3	1.3	16	.1	15.9		18.9	1	17.9	.1	18	— .1	18.1	.3	17.8
4	15.4		17.3	1.1	16.2	.0	16.2		18.1	.2	17.9	.1	17.8	— .4	18.2	.3	17.9
3	15.3		17.2	.6	16.6	.0	16.6		17.9	.1	17.8	.2	18	— .3	18.3	.3	18
2	15.6		17.4	.6	16.8	.1	16.9		17.7	.1	17.8	.2	18	— .2	18.2	.2	18
1	15.7		17.4	.3	17.1	.1	17.2		17.6	.2	17.8	.2	18	— .1	18.1	.0	18.1
1th 1	15.9		17.4	.3	17.1	.0	17.1		17.6	.2	17.8	.3	18.1	— .1	18.2	.1	18.1
2	15.7		17.2	.1	17.1	.1	17		17.8	.2	18	.2	18.2	— .2	18.4	.3	18.1
3	15.7		17.2	.0	17.2	.3	16.9		18	.1	18.1	.2	18.3	— .2	18.5	.4	18.1
4	15.4		17.2	.2	17	.7	16.3		17.8	.3	18.1	.1	18.2	— .2	18.4	.5	17.9
5	15.5		17.3	.6	16.7	.7	16		18.9	.1	19	.9	18.1	— .1	18.2	.4	17.8
6	15.3		17.2	.9	16.3	.5	15.8		20.8	1.5	19.3	1.1	18.2	.0	18.2	.6	17.6
7	15.2		17.2	1.3	15.9	.5	15.4		20.6	1.8	18.8	.8	18	.1	17.9	.5	17.4
8	14.7		17.3	1.7	15.6	.5	15.1		20	1.6	18.4	.6	17.8	.2	17.6	.5	17.1
9	14.5		17.3	1.7	15.6	.6	15		19.9	1.7	18.2	.3	17.9	.3	17.6	.9	16.7
10	13.8		17.3	1.6	15.7	.8	14.9		18.6	1.4	17.2	.1	17.1	— .1	17.2	1.1	16.1
Average deposit				1.02		.30				.70		.36		— .07		.54	
Annual rate				.51		.30				.42		.36		— .21		.93	

Middle division, section 13.

[Part of old channel. First dredged as part of straight channel in May and June, 1890.]

10-foot intervals from axis.	Oct. and Nov., 1887.		June 23, 1890.		June 24, 1891.	Deposit.	June, 1892.	Deposit.	June 23, 1893.		Sept. 29, 1894.	Deposit.	June 13, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 21, 1898.
North 10.	8.8	Dredged, May and June, 1890.	16.4	....	16.2	2	14.2	—0.4	14.6	Dredged in summer, 1894.	18	0.7	17.3	0.2	17.1	—0.3	17.4	1.5	15.9
9.	9.3		16.7	....	16.5	1.8	14.7	— .1	14.8		19.2	1.2	18	.5	17.5	— .1	17.6	1.2	16.4
8.	9.8		16.8	....	16.7	1.7	15	.0	15		19.6	1.4	18.2	.7	17.5	— .2	17.7	.9	16.8
7.	10.2		16.7	....	16.7	1.3	15.4	.1	15.3		19.7	1.2	18.5	.7	17.8	.0	17.8	.6	17.2
6.	10.7		16.9	....	16.7	1.2	15.5	— .1	15.6		20	.9	19.1	1.2	17.9	.1	17.8	.5	17.3
5.	11.4		17.3	....	17	1.2	15.8	— .6	16.4		18.8	.5	18.3	.6	17.7	— .2	17.9	.6	17.3
4.	12.5		17.5	....	17.5	1.3	16.2	— .7	16.9		17.6	—.5	18.1	.3	17.8	— .3	18.1	.5	17.6
3.	13.4		17.1	....	17.8	1.2	16.6	— .4	17		18	.0	18	.1	17.9	— .3	18.2	.4	17.8
2.	13.8		16	.....	17.6	.6	17	— .0	17		17.8	.0	17.8	—.2	18	— .2	18.2	.3	17.9
1.	14.2		15	.....	17.5	.4	17.1	— .1	17.2		17.2	—.3	17.5	—.5	18	— .2	18.2	.2	18
South 1	14.9		14.9	.....	17.5	.3	17.2	— .1	17.3		17.4	—.2	17.6	—.5	18.1	— .1	18.2	.2	18
2.	15.1		15.5	.....	17.2	.1	17.1	— .1	17.2		17.4	—.2	17.6	—.6	18.2	— .1	18.3	.2	18.1
3.	15.6		16.1	.....	17	.1	17.1	.1	17		18	—.3	18.3	—.1	18.4	.1	18.3	.2	18.1
4.	15.5		16.4	.....	17.2	.2	17	.3	16.7		18.2	.0	18.2	.2	18	.0	18	.0	18
5.	15.3		16.5	.....	17.2	.5	16.7	.4	16.3		17.6	—.2	17.8	—.1	17.9	— .2	18.1	.2	17.9
6.	15.0		16.4	.....	17.3	.8	16.5	.5	16		18.8	.3	18.5	.4	18.1	.0	18.1	.4	17.7
7.	14.9		16.1	.....	17.4	1.1	16.3	.5	15.8		19.9	.9	19	1	18	.0	18	.4	17.6
8.	14.5		15.6	.....	17.4	1.4	16	.4	15.6		20	1.2	18.8	.9	17.9	.0	17.9	.5	17.4
9.	14.1		15	.....	17.4	1.5	15.9	.5	15.4		19.7	1.1	18.6	.7	17.9	.0	17.9	.6	17.3
10.	13.3		14.5	.....	17.1	1.4	15.7	— .2	15.9		19.4	1	18.4	.7	17.7	.0	17.7	.7	17
Average deposit	....		....	.....	....	1	....	.00	....	....	....	.44	....	.31	....	— .10	....	.51	....
Annual rate	....		....	.....	....	1	....	.00	....	....	....	.25	....	.31	....	— .30	....	.87	....

Middle division, section 12.

[Part of old channel. First dredged as part of straight channel in May and June, 1890.]

10-foot intervals from axis.	Oct. and Nov., 1887.		June 23, 1890.		June 24, 1891.	Deposit.	June, 1892.	Deposit.	June 23, 1893.		Sept. 29, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 21, 1898.
North 10...	9.2	Dredged, May and June, 1890.	16.2	....	15.3	1.1	14.2	0.0	14.2	Dredged in summer, 1894.	18.4	0.2	18.2	1.2	17	—0.3	17.3	0.9	16.
9...	9.1		16.6	....	16	1.4	14.6	.1	14.5		19.5	1.1	18.4	.8	17.6	— .1	17.7	1.0	16.
8...	9.3		16.2	....	16.2	1.3	14.9	— .2	15.1		19.7	1.1	18.6	.8	17.8	— .1	17.7	.8	16
7...	9.9		16.3	....	16.4	1.3	15.1	— .2	15.3		19.7	.7	19	1.1	17.9	— .1	18	.9	17
6...	10.6		16.5	....	16.3	.8	15.5	—.1	15.6		20.3	1.1	19.2	1.4	17.8	— .3	18.1	.9	17
5...	11.6		17	....	16.7	.7	16	.0	16		18.9	.3	18.6	1	17.6	— .4	18	.8	17
4...	12.6		17	....	16.9	.4	16.5	.1	16.4		17.8	—.2	18	.2	17.8	— .3	18.1	.6	17
3...	13.1		16.9	....	16.9	.2	16.7	.0	16.7		17.8	—.1	17.9	.1	17.8	— .3	18.1	.2	17
2...	13.5	.....	15	.....	17	.1	16.9	—.1	17		17.5	.1	17.4	—.3	17.7	— .4	18.1	.1	17
1...	14.3	.....	14.5	.....	17.1	.1	17	—.1	17.1		17	—.5	17.5	—.2	17.7	— .3	18	.1	17
South 1...	14.7	.....	15.2	.....	17.2	.0	17.2	.0	17.2		17.1	—.5	17.6	—.2	17.8	— .3	18.1	.2	17
2...	15	.....	15.2	.....	17.5	.4	17.1	— .2	17.3		17.4	—.7	18.1	.0	18.1	— .2	18.3	.2	17
3...	15.3	.....	16.1	.....	17.5	.5	17	— .2	17.2		17.8	—.6	18.4	.2	18.2	— .1	18.3	.1	17
4...	15.2	.....	16.2	.....	17.4	.5	16.9	— .1	17		18.2	—.4	18.6	.6	18	— .3	18.3	.3	17
5...	15.3	.....	16.1	.....	17.3	.5	16.8	.1	16.7		18.4	—.2	18.6	.7	17.9	— .4	18.3	.5	17
6...	15.1	.....	15.7	.....	17.2	.6	16.6	.2	16.3		19.3	—.1	19.4	1.3	18.1	— .2	18.3	.6	17
7...	14.8	.....	15.2	.....	17.4	1	16.4	.4	16		20.2	1	19.2	1.2	18	— .2	18.2	.7	17
8...	13.8	.....	14.7	.....	17.5	1.5	16	.2	15.8		20.4	1.3	19.1	1.2	17.9	.0	17.9	.5	17
9...	13.4	.....	14.3	.....	17.2	1.4	15.8	.3	15.5		20.2	1.2	19	1.2	17.8	.1	17.7	.4	17
10...	13.0	.....	13.9	.....	17	1.2	15.8	.4	15.4		19.5	.8	18.7	1.4	17.3	.2	17.1	.4	17
Average deposit	....	.....	....	.....	....	.75	....	.04	....	....	....	.28	....	.68	....	— .19	....	.51	....
Annual rate	....	.....	....	.....	....	.75	....	.04	....	....	....	.16	....	.68	....	— .57	....	.87	....

Middle division, section 7.

[Part of old channel. First dredged as part of straight channel in Oct. and Nov., 1889.]

10-foot intervals from axis.	Oct. and Nov., 1887.		Nov. 11, 1889.	Deposit.	June, 1892.	Deposit.	June 21, 1893.		Sept. 28, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10....	11.2	Dredged in Oct. and Nov., 1889.	17.2	2	15.2	0.6	14.6	Dredged in summer, 1894.	19.2	1	18.2	1	17.2	0.4	16.8	0.4	16.4
9....	11.9		17.5	1.9	15.6	.9	14.7		19.3	1	18.3	.9	17.4	.4	17	.3	16.7
8....	12.1		17.5	1.8	15.7	.9	14.8		19.3	1	18.3	.7	17.6	.4	17.2	.4	16.8
7....	13.4		17.3	1.6	15.7	.6	15.1		19.6	1.2	18.4	.4	18	.5	17.5	.5	17
6....	13.5		16.9	1.2	15.7	.2	15.5		18.9	.4	18.5	.4	18.1	.4	17.7	.6	17.1
5....	13.8		16.9	1	15.9	.1	15.8		17.9	.3	18.2	.2	18	.2	17.8	.5	17.3
4....	14.5		17.1	1	16.1	.0	16.1		18.1	.1	18.2	.0	18.2	.3	17.9	.2	17.7
3....	14.8		16.6	.3	16.3	.1	16.4		18.2	.3	18	.1	18.1	.0	18.1	.2	17.9
2....	15.5		16.5	.1	16.6	.4	17		17.6	.3	17.9	.3	18.2	.1	18.1	.1	18
1....	15.8		17.2	.1	17.3	.2	17.5		17.4	.6	18	.3	18.3	.1	18.2	.0	18.2
South 1....	16.5		17.4	.2	17.6	.0	17.6		17.6	.4	18	.4	18.4	.2	18.2	.1	18.1
2....	16.3		17.6	.0	17.6	.2	17.4		17.6	.5	18.1	.2	18.3	.1	18.2	.1	18.1
3....	16.1		17.9	.6	17.3	.4	16.9		17.6	.6	18.2	.0	18.2	.1	18.1	.0	18.1
4....	15.7		17.5	.7	16.8	.5	16.3		17.7	.6	18.3	.3	18	.2	17.8	.1	17.9
5....	15.4		17.4	.9	16.5	.7	15.8		17.8	.1	17.9	.0	17.9	.4	17.5	.1	17.6
6....	14.8		17.6	1.5	16.1	.6	15.5		19	.5	18.5	.5	18	.4	17.6	.3	17.3
7....	14.5		17.8	2	15.8	.5	15.3		19.9	1.1	18.8	.9	17.9	.4	17.5	.4	17.1
8....	14.2		17.7	2.2	15.5	.6	14.9		20	1.4	18.6	.8	17.8	.5	17.3	.4	16.9
9....	14.1		17.4	2	15.4	.8	14.6		19.9	1.5	18.4	.7	17.7	.6	17.1	.4	16.7
10....	14		17.2	2.1	15.1	.8	14.3		19.4	1.2	18.2	.7	17.5	.6	16.9	.4	16.5
Average deposit.....				1.12		.38				.36		.31		.32		.26	
Annual rate.....				.43		.38				.21		.31		.96		.45	

Middle division, section 6.

[Part of old channel. First dredged as part of straight channel in Oct., 1889.]

10-foot intervals from axis.	Oct. and Nov., 1887.		Oct. 29, 1889.	Deposit.	June, 1892.	Deposit.	June 21, 1893.		Sept. 27, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10....	12.3	Dredged in Oct., 1889.	17.3	2.1	15.2	1.2	14	Dredged in summer, 1894.	19	1.3	17.7	0.7	17	0.9	16.1	0.7	15.4
9....	12.7		16.6	1.5	15.1	.9	14.2		19.6	1.4	18.2	1	17.2	.6	16.6	.8	15.8
8....	13.3		16.2	1.1	15.1	.9	14.2		19.5	1.2	18.3	.9	17.4	.7	16.7	.4	16.3
7....	13.5		16.7	1.3	15.4	1.1	14.3		19.7	1.1	18.6	1.1	17.5	.5	17	.4	16.6
6....	13.9		16.8	1.1	15.7	1.1	14.6		19.8	1	18.8	1	17.8	.5	17.3	.4	16.9
5....	14.1		17.2	1.2	16	.9	15.1		18.5	.3	18.2	.5	17.7	.2	17.5	.3	17.2
4....	14.6		17.3	1.1	16.2	.8	15.4		17.3	.5	17.8	.0	17.8	.1	17.7	.0	17.7
3....	15		17.4	.8	16.6	.8	15.8		17.8	.2	18	.1	18.1	.0	18.1	.1	18
2....	15.6		17.6	.5	17.1	.8	16.3		18.2	.0	18.2	.2	18.4	.1	18.3	.3	18
1....	16.1		17.7	.4	17.3	.4	16.9		17.6	.5	18.1	.2	18.3	.1	18.4	.3	18.1
South 1....	16.5		17.6	.2	17.4	.2	17.2		17.3	.8	18.1	.3	18.4	.2	18.2	.2	18
2....	16.2		17.7	.7	17	.2	17.2		17.5	.7	18.2	.2	18.4	.2	18.2	.3	18
3....	15.8		17.7	.9	16.8	.2	17		18	.2	18.2	.1	18.3	.2	18.1	.1	18
4....	15.4		17.6	1.1	16.5	.2	16.7		17.8	.2	18	.1	17.9	.1	17.8	.0	17.8
5....	14.5		17.6	1.3	16.3	.3	16		17.4	.4	17.8	.2	17.6	.0	17.6	.1	17.5
6....	13.8		17.4	1.8	15.6	.0	15.6		18.4	.0	18.4	.6	17.8	.4	17.4	.3	17.1
7....	13.8		17.3	2	15.3	.3	15		19.1	.9	18.2	.5	17.7	.5	17.2	.4	16.8
8....	13.7		17.2	1.9	15.3	.6	14.7		19.2	1.3	17.9	.5	17.4	.5	16.9	.4	16.5
9....	13.8		16.7	1.6	15.1	.7	14.4		19.2	1.4	17.8	.7	17.1	.4	16.7	.4	16.3
10....	13.7		16.4	1.3	15.1	.9	14.2		19.2	1.3	17.9	1	16.9	.4	16.5	.7	15.8
Average deposit.....				1.20		.56				.38		.38		.32		.32	
Annual rate.....				.45		.56				.22		.38		.96		.55	

Middle division, section 9.

[Part of old channel. First dredged as part of straight channel in Nov., 1889, Apr. and May, 1890.]

10-foot intervals from axis.	Oct. and Nov., 1887.		June 3, 1890.	Deposit.	June, 1892.	Deposit.	June 21, 1893.		Sept. 29, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10	10.5	Dredged in Nov., 1889, and Apr. and May, 1890.	17	3.5	13.5	—1.3	14.8	Dredged in summer, 1894.	18	—.2	18.2	1.4	16.8	—0.3	17.1	0.8	16.3
9	11.1		17.5	3.3	14.2	.6	14.8		19	.6	18.4	1	17.4	—.1	17.5	.9	16.6
8	12.1		17.3	1.4	15.9	.3	15.1		19.3	.7	18.6	.8	17.8	.1	17.7	.9	16.8
7	12.5		17.1	.9	16.2	.9	15.3		19.3	.3	19	.8	18.2	.1	18.1	1	17.1
6	13.2		16.9	.4	16.5	1.1	15.4		19.3	.8	19	.8	18.2	.0	18.2	.7	17.5
5	13.5		16.8	.5	16.3	.3	16		18.2	—.3	18.5	.5	18	.0	18	.6	17.4
4	13.7		17.1	.3	16.3	—.2	16.5		17.7	—.3	18	.0	18	—.1	18.1	.6	17.5
3	14.3		17	.1	16.9	—.1	17		18	—.2	18.2	.1	18.1	—.3	18.4	.6	17.8
2	15		17.2	.1	17.1	—.2	17.3		17.8	—.4	18.2	.0	18.2	—.2	18.4	.5	17.9
1	15.3		16.9	—.4	17.3	—.1	17.4		17.5	—.7	18.2	.0	18.2	—.3	18.5	.5	18
South 1	15.5		16.9	—.6	17.5	.2	17.8		17.8	—.4	18.2	—.2	18.4	—.2	18.6	.7	17.9
2	15.7		17.2	—.2	17.4	.4	17		17.7	—.5	18.2	—.2	18.4	—.1	18.5	.6	17.9
3	15.7		17.2	—.1	17.3	.6	16.7		17.9	—.6	18.5	.3	18.2	—.2	18.4	.6	17.8
4	15.5		17.2	.1	17.1	.7	16.4		17.9	—.7	18.6	.6	18	—.1	18.1	.4	17.7
5	15.3		17.2	.3	16.9	.8	16.1		17.8	—.9	18.7	.6	18.1	—.1	18	.5	17.5
6	14.7		17.2	.6	16.6	1	15.6		19	—.1	18.9	.9	18	.0	18	.6	17.4
7	14.3		17.2	.9	16.3	1.1	15.2		20	1.2	18.8	1	17.8	—.1	17.9	.8	17.1
8	13.8		17	1	16	1.3	14.7		19.7	1.2	18.5	.8	17.7	.1	17.6	.8	16.8
9	13.7		16.8	.9	15.9	1.5	14.4		19.2	.8	18.4	.9	17.5	.1	17.4	.9	16.5
10	13.8		16.6	1.1	15.5	1.3	14.2		18.6	.6	18	1	17	.2	16.8	.7	16.1
Average deposit				.73		.43				.06		.56		—.06		.68	
Annual rate				.87		.43				.03		.56		—.18		1.17	

Middle division, section 8.

[Part of old channel. First dredged as part of straight channel in Nov., 1889.]

10-foot intervals from axis.	Oct. and Nov., 1887.		May 7, 1890.	Deposit.	June, 1892.	Deposit.	June 21, 1893.		Sept. 29, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10	11.0	Dredged in Nov., 1889.	17.1	1.7	15.4	0.9	14.5	Dredged in summer, 1894.	18.6	0.3	17.8	0.5	17.3	0.3	17	0.4	16.6
9	11.3		17.2	1.7	15.5	1.0	14.5		19.3	.9	18.4	.8	17.6	.2	17.4	.6	16.8
8	11.9		16.8	1.2	15.6	.9	14.7		19.3	.6	18.7	.9	17.8	.4	17.4	.4	17
7	12.4		16.5	.9	15.6	.6	15		19.4	.5	18.9	.8	18.1	.3	17.8	.6	17.2
6	13.2		16.4	.7	15.7	.3	15.4		19.4	.6	18.8	.8	18	.2	17.8	.6	17.2
5	13.7		16.1	.3	15.8	.1	15.7		18	—.2	18.2	.2	18	.4	17.6	.1	17.5
4	13.9		16.1	—.1	16.2	.1	16.1		17.9	—.1	18	.0	18	.2	17.8	.1	17.7
3	14.0		16.5	.0	16.5	.1	16.4		18	.0	18	.0	18	.0	18	.0	18
2	14.8		16.7	—.2	17	.2	16.8		17.2	—.3	18	.0	18	—.1	18.1	.0	18.1
1	15.5		16.9	—.5	17.4	.1	17.3		17.3	—.7	18	—.2	18.2	.1	18.1	.1	18
South 1	16.0		17.2	—.2	17.4	.0	17.4		17.5	—.6	18.1	—.2	18.3	.1	18.2	.2	18
2	16.3		17.3	.1	17.2	—.1	17.3		17.5	—.5	18	—.3	18.3	.1	18.2	.3	17.9
3	16.0		17.1	.1	17	.1	16.9		18.2	—.2	18.4	.1	18.3	.2	18.1	.2	17.9
4	15.6		17.1	.3	16.8	.4	16.4		18.2	—.2	18.4	.2	18.2	.4	17.8	.0	17.8
5	15.3		17.3	.3	16.5	.6	15.9		17.8	—.5	18.3	.4	17.9	.2	17.7	.0	17.7
6	14.7		17.5	1.5	16	.6	15.4		19.2	.3	18.9	.8	18.1	.4	17.7	.1	17.6
7	14.4		17.4	1.9	15.5	.6	14.9		19.7	.9	18.8	.8	18	.3	17.7	.2	17.5
8	13.8		17.2	2.1	15.1	.4	14.7		19.3	.8	18.5	.7	17.8	.4	17.4	.2	17.3
9	13.4		17	1.9	15.1	.5	14.6		19.2	.7	18.5	.9	17.6	.6	17	.0	17
10	13.1		16.6	1.6	15	.6	14.4		18.4	.2	18.2	.9	17.3	.7	16.6	.0	16.6
Average deposit				.78		.40				.12		.40		.27		.20	
Annual rate				.88		.40				.07		.40		.81		.84	

Middle division, section 3.

[Part of old channel. First dredged as part of Straight Channel in June and July, 1889.]

Feet intervals from axis.	Oct. and Nov., 1887.		Oct. 2, 1889.	Deposit.	June, 1892.	Deposit.	June 20, 1893.		Sept. 25, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10	15.1	Dredged in June and July, 1889.	17	2.4	14.6	1.2	13.4	Dredged in summer, 1894.	17	0.7	16.3	0.1	16.2	0.7	15.5	0.2	15.3
9	15.1		17.1	2.2	14.9	1.4	13.5		18.5	1.1	17.4	.6	16.8	.1	16.7	.7	16
8	15.6		17.1	2	15.1	1	14.1		18.8	.9	17.9	.7	17.2	.3	16.9	.4	16.5
7	15.7		17.1	1.8	15.3	1	14.3		19.2	.9	18.3	1	17.3	.2	17.1	.4	16.7
6	15.9		17.2	1.5	15.7	.8	14.9		19.6	1.2	18.4	1	17.4	—.1	17.5	.6	16.9
5	16		17.4	1.5	15.9	.5	15.4		19.5	.9	18.6	.8	17.8	.1	17.7	.4	17.3
4	16.2		17.7	1.4	16.3	.6	15.7		19.4	.8	18.6	.8	17.8	—.1	17.9	.2	17.7
3	15.8		17.6	1	16.6	.6	16		18.8	.6	18.2	.4	17.8	—.3	18.1	.2	17.9
2	15.8		17.4	1.2	16.2	—.3	16.5		17.9	.2	17.7	—.3	18	.0	18	.1	17.9
1	15.1		17.3	.1	17.2	.2	17		17	—.5	17.5	—.7	18.2	.2	18	.0	18
South 1	14.9		17.1	.2	16.9	.2	16.7		16.6	—.8	17.4	—.7	18.1	.1	18	.1	17.9
2	14.7		16.9	.4	16.5	.3	16.2		16.7	—.8	17.5	—.4	17.9	.0	17.9	.1	17.8
3	14.4		16.9	1	15.9	.3	15.6		17.3	—.3	17.6	—.1	17.7	.1	17.6	.1	17.5
4	14.1		16.9	1.5	15.4	.3	15.1		17.8	.4	17.4	—.1	17.5	.2	17.3	.2	17.1
5	14		16.7	1.5	15.2	.6	14.6		17.9	.4	17.5	.1	17.4	.3	17.1	.2	16.9
6	13.2		16.5	1.6	14.9	.5	14.4		18.6	.4	18.2	.7	17.5	.4	17.1	.3	16.8
7	12.6		16.4	1.7	14.7	.4	14.3		19.1	.8	18.3	.9	17.4	.4	17	.4	16.6
8	11.7		16.3	1.6	14.7	.9	13.8		19.2	1	18.2	1	17.2	.3	16.9	.5	16.4
9	11.5		16.4	1.8	14.6	.7	13.9		19.2	1.1	18.1	.8	17.3	.4	16.9	.6	16.3
10	11.1		16.6	2.1	14.5	.6	13.9		18.0	—.2	18.2	.9	17.3	.6	16.7	1.1	15.6
Average deposit				1.42		.60				.44		.38		.20		.34	
Annual rate				.53		.60				.25		.38		.60		.58	

Outer division, section 4.

[Oct. and Nov., 1887, average depth before dredging, 10.8. Dredged in May and June, 1891.]

Feet intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 17, 1898.
15						Dredged May to Nov., 1893.				Widened and deepened, 1897.	19.9	0.9	19
14											19.7	.7	19
13											19.3	.7	18.6
12											18.6	.8	17.8
11											18	.1	17.9
10	17.2	1.7	15.5	0.8	14.7		16.2	0.7	15.5		18.2	—.6	18.8
9	17.2	1.6	15.6	.8	14.8		16.5	.7	15.8		19.9	.6	19.3
8	16.4	.8	15.6	.8	14.8		16.6	.5	16.1		19.9	.4	19.5
7	16.4	.8	15.6	.8	14.8		16.9	.7	16.2		19.8	.1	19.7
6	16.6	1.1	15.5	.6	14.9		16.9	.2	16.7		19.8	.1	19.7
5	16.7	1.4	15.3	.3	15		17.4	.1	17.3		19.9	.2	19.7
4	16.8	1.4	15.4	.4	15		17.8	.1	17.7		19.9	.8	19.1
3	16.7	1.4	15.3	.3	15		18.4	.1	18.3		19	.7	18.3
2	16.9	1.6	15.3	.3	15		18.5	—.1	18.6		18.3	.2	18.1
1	17.0	1.6	15.4	.3	15.1		18.4	—.1	18.5		18.1	—.1	18.2
1	16.8	1.4	15.4	.3	15.1		18.1	—.1	18.2		17.8	—.2	18
2	16.8	1.5	15.3	.2	15.1		18	.0	18		17.3	—.5	17.8
3	16.6	1.2	15.4	.4	15		17.9	.2	17.7		17.3	—.9	18.2
4	16.5	1.2	15.3	.4	14.9		17.6	.6	17		18.4	—.9	19.3
5	16.5	1.3	15.2	.5	14.7		16.9	.7	16.2		19.8	.0	19.8
6	16.5	1.4	15.1	.5	14.6		16.4	.8	15.6		20	.4	19.6
7	16.5	1.7	14.8	.5	14.3		15.8	.6	15.2		20	.7	19.3
8	16.2	1.7	14.5	.3	14.2		15.6	.6	15		19.9	.6	19.3
9	16.1	.9	15.2	1	14.2		15.4	.7	14.7		18.6	—.1	18.7
10	15.0	—.3	15.3	1	14.3		15.1	1.1	14		16.9	.0	16.9
											17	.6	16.4
											17.8	1.1	16.7
											18.8	.6	18.2
											19.3	.6	18.7
											19.7	.9	18.8
		1.27		.52				.41				.28	
		1.52		.52				.41				.48	

Outer division, section 5.

[Oct. and Nov., 1887, average depth before dredging, 10.7. Dredged in June and July, 1891.]

10-foot intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 18, 1898.
North 15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened in 1897.	19.8	0.5	19.3
14	.....	.....	.....	.....	.....		.....	.....			19.4	.2	19.2
13	.....	.....	.....	.....	.....		.....	.....			18.9	.6	18.3
12	.....	.....	.....	.....	.....		.....	.....			18.3	.2	18.1
11	.....	.....	.....	.....	.....		.....	.....			18.4	.3	18.7
10	17.2	1.3	15.9	1.6	14.3		16.3	.....			19.4	.0	19.4
9	16.9	1	15.9	.7	15.2		16.4	.....			19.7	.2	19.5
8	16.7	.9	15.8	.6	15.2		16.4	.....			19.7	.1	19.6
7	16.7	.9	15.8	.6	15.2		16.5	.....			20	.2	19.8
6	16.9	1.1	15.8	.6	15.2		16.8	.....			19.9	.0	19.9
5	17	1.6	15.4	.3	15.1		17.4	0.3	17.1		19.7	.0	19.7
4	16.8	1.4	15.4	.3	15.1		17.9	.3	17.6		19	.0	19
3	16.9	1.5	15.4	.3	15.1		18.2	.2	18		18	.3	18.3
2	17.2	1.8	15.4	.1	15.3		18.3	.1	18.2		17.6	.7	18.3
1	17.5	1.9	15.6	.2	15.4		18.4	.0	18.4		18	.6	18.6
South 1	17	1.5	15.5	.0	15.5		18.5	.1	18.4		17.9	.6	18.5
2	17	1.5	15.5	.1	15.4		18.4	.0	18.4		17.4	.7	18.1
3	16.7	1.1	15.6	.4	15.2		17.8	.3	18.1		17.7	.6	18.3
4	16.7	1.2	15.5	.3	15.2		17	.4	17.4		19.4	.7	18.7
5	16.9	1.6	15.3	.1	15.2		16.6	.1	16.5		20.2	.7	19.5
6	16.8	1.5	15.3	.1	15.2		16.3	.4	15.9		20	.1	20.1
7	16.9	1.7	15.2	.2	15		16.3	.7	15.6		20	.1	20.1
8	16.9	.8	16.6	1.6	15		16	.6	15.4		19.5	.2	19.7
9	16.8	.3	17.1	1.4	15.7		15.6	.6	15		19.1	.0	19.1
10	16.4	.8	17.2	1.2	16		15.2	.4	14.8		19.2	.3	18.9
11	.....	.....	.....	.....	.....		.....	.....	.....		19.4	.4	19
12	.....	.....	.....	.....	.....		.....	.....	.....		19.6	.1	19.5
13	.....	.....	.....	.....	.....		.....	.....	.....		19.9	.1	19.8
14	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.2	20
15	.....	.....	.....	.....	.....		.....	.....	.....		20.3	.0	20.3
Av. deposit	.....	1.14	.....	.54	.....	.....	.....	.21	.....	.....	.....	.01	.....
Annual rate	.....	1.37	.....	.54	.....	.....	.....	.21	.....	.....	.....	.02	.....

Outer division, section 6.

[Oct. and Nov., 1887, average depth before dredging, 11.0. Dredged May, June, and July, 1891.]

10-foot intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 18, 1898.
North 15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	19.8	0.2	19.6
14	.....	.....	.....	.....	.....		.....	.....			19.7	.4	19.3
13	.....	.....	.....	.....	.....		.....	.....			19.2	.3	18.9
12	.....	.....	.....	.....	.....		.....	.....			18.7	.2	18.5
11	.....	.....	.....	.....	.....		.....	.....			18.8	.1	18.7
10	16.8	0.6	16.2	1.4	14.8		16.4	.....			19.4	.3	19.1
9	17	.6	16.4	1.2	15.2		16.5	.....			19.7	.4	19.3
8	17.1	.9	16.2	.9	15.3		16.8	.....			20.1	.6	19.5
7	16.7	1	15.7	.5	15.2		16.9	.....			20.2	.3	19.9
6	16.3	.5	15.8	.6	15.2		17	.....			20.1	.0	20.1
5	16.1	.7	15.4	.3	15.1		17.1	0.6	16.5		19.7	.4	19.3
4	16	.4	15.6	.5	15.1		17.7	.6	17.1		18.7	.3	18.4
3	16.2	.4	15.8	.5	15.3		18.2	.5	17.7		17.7	.7	18.4
2	16.7	.7	16	.6	15.4		18.3	.2	18.1		18	.5	18.5
1	16.8	.8	16	.7	15.3		18	.2	18.2		18.2	.2	18.4
South 1	16.3	.4	15.9	.6	15.3		17.3	.8	18.1		18	.1	18.1
2	16.5	.7	15.8	.6	15.2		18.1	.7	18.8		17.8	.5	18.3
3	16.9	1.1	15.8	.7	15.1		17.8	.2	18		17.8	.9	18.7
4	16.8	1	15.8	.8	15		17.7	.1	17.6		18.3	1.1	19.4
5	16.6	.9	15.7	.9	14.8		17.2	.0	17.2		19.8	.0	19.8
6	16.5	1	15.5	.8	14.7		16.7	.3	16.4		20.1	.1	20
7	16.8	1.4	15.4	.8	14.6		15.9	.1	15.8		20.2	.7	19.5
8	16.8	1.6	15.2	.7	14.5		15.7	.5	15.2		19.5	.6	18.9
9	16.4	1.2	15.2	.9	14.3		15.5	.5	15		18.7	.0	18.7
10	16.2	1.2	15	.8	14.2		14.8	.6	14.2		18	.6	18.6
11	.....	.....	.....	.....	.....		.....	.....	.....		18.8	.2	18.6
12	.....	.....	.....	.....	.....		.....	.....	.....		19.5	.5	19
13	.....	.....	.....	.....	.....		.....	.....	.....		20	.8	19.2
14	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.6	19.6
15	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.5	19.7
Av. deposit	.....	.86	.....	.74	.....	.....	.....	.14	.....	.....	.....	.19	.....
Annual rate	.....	1.03	.....	.74	.....	.....	.....	.14	.....	.....	.....	.17	.....

Middle division, section 3.

[Part of old channel. First dredged as part of Straight Channel in June and July, 1889.]

10-foot intervals from axis.	Oct. and Nov., 1887.		Oct. 2, 1889.	Deposit.	June, 1892.	Deposit.	June 20, 1893.		Sept. 25, 1894.	Deposit.	June 12, 1896.	Deposit.	June, 1897.	Deposit.	Oct., 1897.	Deposit.	May 20, 1898.
North 10	15.1	Dredged in June and July, 1889.	17	2.4	14.6	1.2	13.4	Dredged in summer, 1894.	17	0.7	16.3	0.1	16.2	0.7	15.5	0.2	15.3
9	15.1		17.1	2.2	14.9	1.4	13.5		18.5	1.1	17.4	.6	16.8	.1	16.7	.7	16
8	15.6		17.1	2	15.1	1	14.1		18.8	.9	17.9	.7	17.2	.3	16.9	.4	16.5
7	15.7		17.1	1.8	15.3	1	14.3		19.2	.9	18.3	1	17.3	.2	17.1	.4	16.7
6	15.9		17.2	1.5	15.7	.8	14.9		19.6	1.2	18.4	1	17.4	—.1	17.5	.6	16.9
5	16		17.4	1.5	15.9	.5	15.4		19.5	.9	18.6	.8	17.8	.1	17.7	.4	17.3
4	16.2		17.7	1.4	16.3	.6	15.7		19.4	.8	18.6	.8	17.8	—.1	17.9	.2	17.7
3	15.8		17.6	1	16.6	.6	16		18.8	.6	18.2	.4	17.8	—.3	18.1	.2	17.9
2	15.8		17.4	1.2	16.2	—.2	16.5		17.9	.2	17.7	—.3	18	.0	18	.1	17.9
1	15.1		17.3	.1	17.2	.2	17		17	—.5	17.5	—.7	18.2	.2	18	.0	18
South 1	14.9		17.1	.2	16.9	.2	16.7		16.6	—.8	17.4	—.7	18.1	.1	18	.1	17.9
2	14.7		16.9	.4	16.5	.3	16.2		16.7	—.8	17.5	—.4	17.9	.0	17.9	.1	17.8
3	14.4		16.9	1	15.9	.3	15.6		17.3	—.3	17.6	—.1	17.7	.1	17.6	.1	17.5
4	14.1		16.9	1.5	15.4	.3	15.1		17.8	.4	17.4	—.1	17.5	.2	17.3	.2	17.1
5	14		16.7	1.5	15.2	.6	14.6		17.9	.4	17.5	.1	17.4	.3	17.1	.2	16.9
6	13.2		16.5	1.6	14.9	.5	14.4		18.6	.4	18.2	.7	17.5	.4	17.1	.3	16.8
7	12.6		16.4	1.7	14.7	.4	14.3		19.1	.8	18.3	.9	17.4	.4	17	.4	16.6
8	11.7		16.3	1.6	14.7	.9	13.8		19.2	1	18.2	1	17.2	.3	16.9	.5	16.4
9	11.5		16.4	1.8	14.6	.7	13.9		19.2	1.1	18.1	.8	17.3	.4	16.9	.6	16.3
10	11.1		16.6	2.1	14.5	.6	13.9		18.0	—.2	18.2	.9	17.3	.6	16.7	1.1	15.6
Average deposit				1.42		.60				.44		.38		.20		.34	
Annual rate				.53		.60				.25		.38		.60		.58	

Outer division, section 4.

[Oct. and Nov., 1887, average depth before dredging, 10.8. Dredged in May and June, 1891.]

10-foot intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 17, 1898.
North 15						Dredged May to Nov., 1893.				Widened and deepened, 1897.	19.9	0.9	19
14											19.7	.7	19
13											19.3	.7	18.6
12											18.6	.8	17.8
11											18	.1	17.9
10	17.2	1.7	15.5	0.8	14.7		16.2	0.7	15.5		18.2	—.6	18.8
9	17.2	1.6	15.6	.8	14.8		16.5	.7	15.8		19.9	.6	19.3
8	16.4	.8	15.6	.8	14.8		16.6	.5	16.1		19.9	.4	19.5
7	16.4	.8	15.6	.8	14.8		16.9	.7	16.2		19.8	.1	19.7
6	16.6	1.1	15.5	.6	14.9		16.9	.2	16.7		19.8	.1	19.7
5	16.7	1.4	15.3	.3	15		17.4	.1	17.3		19.9	.2	19.7
4	16.8	1.4	15.4	.4	15		17.8	.1	17.7		19.9	.8	19.1
3	16.7	1.4	15.3	.3	15		18.4	.1	18.3		19	.7	18.3
2	16.9	1.6	15.3	.3	15		18.5	—.1	18.6		18.3	.2	18.1
1	17.0	1.6	15.4	.3	15.1		18.4	—.1	18.5		18.1	—.1	18.2
South 1	16.8	1.4	15.4	.3	15.1		18.1	—.1	18.2		17.8	—.2	18
2	16.8	1.5	15.3	.2	15.1		18	.0	18		17.3	—.5	17.8
3	16.6	1.2	15.4	.4	15		17.9	.2	17.7		17.3	—.9	18.2
4	16.5	1.2	15.3	.4	14.9		17.6	.6	17		18.4	—.9	19.3
5	16.5	1.3	15.2	.5	14.7		16.9	.7	16.2		19.8	.0	19.8
6	16.5	1.4	15.1	.5	14.6		16.4	.8	15.6		20	.4	19.6
7	16.5	1.7	14.8	.5	14.3		15.8	.6	15.2		20	.7	19.3
8	16.2	1.7	14.5	.3	14.2		15.6	.6	15		19.9	.6	19.3
9	16.1	.9	15.2	1	14.2		15.4	.7	14.7		18.6	—.1	18.7
10	15.0	—.3	15.3	1	14.3		15.1	1.1	14		16.9	.0	16.9
11											17	.6	16.4
12											17.8	1.1	16.7
13											18.8	.6	18.2
14											19.3	.6	18.7
15											19.7	.9	18.8
Average deposit		1.27		.52				.41				.28	
Annual rate		1.52		.52				.41				.48	

Outer division, section 5.

and Nov., 1887, average depth before dredging, 10.7. Dredged in June and July, 1891.]

10-foot intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened in 1897.	19.8	0.5	19.3
14	.....	.....	.....	.....	.....		.....	.....			19.4	.2	19.2
13	.....	.....	.....	.....	.....		.....	.....			18.9	.6	18.3
12	.....	.....	.....	.....	.....		.....	.....			18.3	.2	18.1
11	.....	.....	.....	.....	.....		.....	.....			18.4	.3	18.7
10	17.2	1.3	15.9	1.6	14.3		16.3	.....			19.4	.0	19.4
9	16.9	1	15.9	.7	15.2		16.4	.....			19.7	.2	19.5
8	16.7	.9	15.8	.6	15.2		16.4	.....			19.7	.1	19.6
7	16.7	.9	15.8	.6	15.2		16.5	.....			20	.2	19.8
6	16.9	1.1	15.8	.6	15.2		16.8	.....			19.9	.0	19.9
5	17	1.6	15.4	.3	15.1		17.4	0.3	17.1		19.7	.0	19.7
4	16.8	1.4	15.4	.3	15.1		17.9	.3	17.6		19	.0	19
3	16.9	1.5	15.4	.3	15.1		18.2	.2	18		18	.3	18.3
2	17.2	1.8	15.4	.1	15.3		18.3	.1	18.2		17.6	.7	18.3
1	17.5	1.9	15.6	.2	15.4		18.4	.0	18.4		18	.6	18.6
South 1	17	1.5	15.5	.0	15.5		18.5	.1	18.4		17.9	.6	18.5
2	17	1.5	15.5	.1	15.4		18.4	.0	18.4		17.4	.7	18.1
3	16.7	1.1	15.6	.4	15.2		17.8	.3	18.1		17.7	.6	18.3
4	16.7	1.2	15.5	.3	15.2		17	.4	17.4		19.4	.7	18.7
5	16.9	1.6	15.3	.1	15.2		16.6	.1	16.5		20.2	.7	19.5
6	16.8	1.5	15.3	.1	15.2		16.3	.4	15.9		20	.1	19.9
7	16.9	1.7	15.2	.2	15		16.3	.7	15.6		20	.1	19.9
8	16.9	.3	16.6	1.6	15		16	.6	15.4		19.5	.2	19.7
9	16.8	.3	17.1	1.4	15.7		15.6	.6	15		19.1	.0	19.1
10	16.4	.8	17.2	1.2	16		15.2	.4	14.8		19.2	.3	19.9
11	.....	.....	.....	.....	.....		.....	.....	.....		19.4	.4	19.5
12	.....	.....	.....	.....	.....		.....	.....	.....		19.6	.1	19.5
13	.....	.....	.....	.....	.....		.....	.....	.....		19.9	.1	19.8
14	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.2	20
15	.....	.....	.....	.....	.....		.....	.....	.....		20.3	.0	20.3
Av. deposit	.....	1.14	.....	.54	.....	.....	.....	.21	.....	.....	.....	.01	.....
Annual rate	.....	1.37	.....	.54	.....	.....	.....	.21	.....	.....	.....	.02	.....

Outer division, section 6.

[Oct. and Nov., 1887, average depth before dredging, 11.0. Dredged May, June, and July, 1891.]

10-foot intervals from axis.	July 31, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 14, 1898.
North 15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	19.8	0.2	19.6
14	.....	.....	.....	.....	.....		.....	.....			19.7	.4	19.3
13	.....	.....	.....	.....	.....		.....	.....			19.2	.3	19.0
12	.....	.....	.....	.....	.....		.....	.....			18.7	.2	18.5
11	.....	.....	.....	.....	.....		.....	.....			18.8	.1	18.7
10	16.8	0.6	16.2	1.4	14.8		16.4	.....			19.4	.3	19.1
9	17	.6	16.4	1.2	15.2		16.5	.....			19.7	.4	19.3
8	17.1	.9	16.2	.9	15.3		16.8	.....			20.1	.6	19.5
7	16.7	1	15.7	.5	15.2		16.9	.....			20.2	.3	19.9
6	16.3	.5	15.8	.6	15.2		17	.....			20.1	.0	20.1
5	16.1	.7	15.4	.3	15.1		17.1	0.6	16.5		19.7	.4	19.3
4	16	.4	15.6	.5	15.1		17.7	.6	17.1		18.7	.3	18.4
3	16.2	.4	15.8	.5	15.3		18.2	.5	17.7		17.7	.7	18.4
2	16.7	.7	16	.6	15.4		18.3	.2	18.1		18	.5	18.5
1	16.8	.8	16	.7	15.3		18	.2	18.2		18.2	.2	18.4
South 1	16.3	.4	15.9	.6	15.3		17.3	.8	18.1		18	.1	18.1
2	16.5	.7	15.8	.6	15.2		18.1	.7	18.8		17.8	.5	18.3
3	16.9	1.1	15.8	.7	15.1		17.8	.2	18		17.3	.9	18.7
4	16.8	1	15.8	.8	15		17.7	.1	17.6		18.3	1.1	19.4
5	16.6	.9	15.7	.9	14.8		17.2	.0	17.2		19.8	.0	19.8
6	16.5	1	15.5	.8	14.7		16.7	.3	16.4		20.1	.1	20
7	16.3	1.4	15.4	.8	14.6		15.9	.1	15.8		20.2	.7	19.5
8	16.8	1.6	15.2	.7	14.5		15.7	.5	15.2		19.5	.6	18.9
9	16.4	1.2	15.2	.9	14.3		15.5	.5	15		18.7	.0	18.7
10	16.2	1.2	15	.8	14.2		14.8	.6	14.2		18	.6	18.6
11	.....	.....	.....	.....	.....		.....	.....	.....		18.8	.2	18.6
12	.....	.....	.....	.....	.....		.....	.....	.....		19.5	.5	19
13	.....	.....	.....	.....	.....		.....	.....	.....		20	.8	19.2
14	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.6	19.6
15	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.5	19.7
Av. deposit	.....	.86	.....	.74	.....	.....	.....	.14	.....	.....	.....	.16	.....
Annual rate	.....	1.03	.....	.74	.....	.....	.....	.14	.....	.....	.....	.17	.....

Outer division, section 7.

[Oct. and Nov., 1887, average depth before dredging, 11.4. Dredged in July and Aug., 1891.]

-foot intervals from axis.	Aug. 25, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
erth 15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	Dredging in progress.	.....	Dredging in progress.	.....	20	0.2	19.8
14	.....	.....	.....	.....	.....			.....		.....	20.2	.5	19.7
13	.....	.....	.....	.....	.....			.....		.....	19.7	.8	18.9
12	.....	.....	.....	.....	.....			.....		.....	19.2	.9	18.3
11	.....	.....	.....	.....	.....			.....		.....	18.4	.3	18.1
10	16.5	0.5	16	1.6	14.4			.....		.....	18.1	.0	18.1
9	17.1	.4	16.7	1.3	15.4			.....		.....	18.1	—.3	18.4
8	16.8	.4	16.4	.9	15.5			.....		.....	18.4	—.8	19.2
7	16.4	.3	16.1	.5	15.6		16.9	.....		.....	19.4	—.5	19.9
6	16.3	.2	16.1	.6	15.5		17	.....		.....	20.1	.0	20.1
5	16.5	.2	16.3	.7	15.6		17.4	0.4	17	Widened and deepened, 1897.	20.4	.3	20.1
4	16.5	.2	16.3	.7	15.6		18.1	.3	17.8		19.8	.4	19.4
3	16.5	.5	16	.5	15.5		18.2	.0	18.2		18.6	—.2	18.8
2	16.4	.6	15.8	.3	15.5		18	—.1	18.1		18.1	—.5	18.6
1	16.2	.6	15.6	.2	15.4		17.9	—.3	18.2		18.2	—.2	18.4
uth 1	16.4	.7	15.7	.4	15.3		18	—.6	18.6		18.2	—.1	18.3
2	16.3	.5	15.8	.4	15.3		18.3	—.3	18.6		18.1	—.1	18.2
3	16.3	.6	15.7	.5	15.2		18.4	.0	18.4		17.9	—.7	18.6
4	16.1	.7	15.4	.4	15		18	.4	17.6		18.3	—1.4	19.7
5	16.3	.8	15.5	.5	15		17.5	.3	17.2		19.7	—.3	20
6	16.3	.8	15.5	.5	15		17.5	.6	16.9		20	.0	20
7	16	.5	15.5	.5	15		17.1	.6	16.5		19.9	.1	19.8
8	15.9	—.4	16.5	.9	15.4		16.8	.6	16.2		19.9	.6	19.3
9	16.1	—1.1	17.2	1.0	16.2		16.5	.7	15.8		19.1	.3	18.8
10	16.1	—1.1	17.2	.9	16.3		16.1	.7	15.4		18.8	.1	18.7
11	.....	.....	.....	.....	.....		.....	.....	.....		18.8	.0	18.8
12	.....	.....	.....	.....	.....		.....	.....	.....		19.2	.0	19.2
13	.....	.....	.....	.....	.....		.....	.....	.....		18.8	.0	18.8
14	.....	.....	.....	.....	.....		.....	.....	.....		20.2	.1	20.1
15	.....	.....	.....	.....	.....		.....	.....	.....		20.3	.2	20.1
v. deposit	.....	.30	.....	.67	.....	.....	.....	.22	.....	.....	.....	.01	.....
nnual rate	.....	.40	.....	.67	.....	.....	.....	.20	.....	.....	.....	.02	.....

Outer division, section 8.

[Oct. and Nov., 1887, average depth before dredging, 11.2. Dredging in July and August, 1891.]

-foot intervals from axis.	Aug. 25, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
erth 15	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	20.4	0.3	20.1
14	.....	.....	.....	.....	.....		.....	.....			20.1	.1	20
13	.....	.....	.....	.....	.....		.....	.....			19.4	.2	19.2
12	.....	.....	.....	.....	.....		.....	.....			18.7	.1	18.6
11	.....	.....	.....	.....	.....		.....	.....			18.3	—.2	18.5
10	17.8	0.7	17.1	1.5	15.6		16	.....			18.2	—.1	18.3
9	17.8	.6	17.2	1.3	15.9		16.7	.....			18.1	—.1	18.2
8	17.6	.6	17	1.1	15.9		16.8	.....			19.1	—.2	18.9
7	17.5	.7	16.8	1.1	15.7		17	.....			19.4	—.4	19.8
6	17.3	.6	16.7	1	15.7		17.2	.....			19.5	—.6	20.1
5	17	.5	16.5	.7	15.8		17.3	0.1	17.2		19.5	—.4	19.9
4	16.9	.4	16.5	.7	15.8		17.6	—.3	17.9		18.8	—.1	18.9
3	17	.5	16.5	.8	15.7		18.2	—.2	18.4		18	—.6	18.6
2	16.5	.3	16.2	.4	15.8		18.4	—.3	18.7		18.5	—.3	18.8
1	16.6	.1	16.5	.6	15.9		18.2	—.5	18.7		18.6	—.1	18.7
uth 1	17	.7	16.3	.4	15.9		18	—.6	18.6		18.4	.0	18.4
2	17.3	1.2	16.1	.3	15.8		18.2	—.4	18.6		18.1	—.2	18.3
3	17	1.0	16	.3	15.7		18.3	—.2	18.5		18.1	—1.2	19.3
4	16.8	.8	16	.4	15.6		18.2	.1	18.1		18.9	—.9	19.8
5	17	1.1	15.9	.6	15.3		17.9	.1	17.8		19.8	—.2	20
6	16.9	1.2	15.7	.7	15		17.2	.0	17.2		20.1	.2	19.9
7	16.7	.4	16.3	1.4	14.9		16.9	.1	16.8		19.8	.2	19.6
8	16.7	—1.0	17.7	1.8	15.9		16.7	.1	16.6		19.7	.3	19.4
9	16.4	—1.7	18.1	.6	17.5		16.6	.2	16.4		19.3	.0	19.3
10	15.4	—2.3	17.7	.2	17.5		16.2	.3	15.9		19.4	.3	19.1
11	.....	.....	.....	.....	.....		.....	.....	.....		19.7	.3	19.4
12	.....	.....	.....	.....	.....		.....	.....	.....		19.9	—.1	20
13	.....	.....	.....	.....	.....		.....	.....	.....		20.1	—.2	20.3
14	.....	.....	.....	.....	.....		.....	.....	.....		19.9	—.2	20.1
15	.....	.....	.....	.....	.....		.....	.....	.....		20 1	—.4	19.7
v. deposit	.....	.32	.....	.80	.....	.....	.....	—.10	.....	.....	.....	—.12	.....
nnual rate	.....	.42	.....	.80	.....	.....	.....	—.09	.....	.....	.....	—.21	.....

Outer division, section 9.

[Oct. and Nov., 1887, average depth before dredging, 11.1 feet. Dredged in July, 1889.]

10-foot intervals from axis.		Sept. 4–9, 1889.		Oct. 5, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
North	15	.....	Soundings taken June 13, 1890, and showed no perceptible change. Dredged Aug. and Sept., 1891.	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	20.5	0.1	20.4
	14	.....		.....	.....	.....	.....	.....		.....	.....			20.6	.5	20.1
	13	.....		.....	.....	.....	.....	.....		.....	.....			19.9	.4	19.5
	12	.....		.....	.....	.....	.....	.....		.....	.....			19.7	.9	18.8
	11	.....		.....	.....	.....	.....	.....		.....	.....			18.7	.2	18.5
	10	13.5		18.7	0.9	17.8	1.4	16.4		15.8	.....			18.3	.1	18.4
	9	13.6		18.3	.6	17.7	1.2	16.5		16.3	.....			18.5	.2	18.3
	8	13.4		18	1.1	16.9	.4	16.5		16.4	.....			19.4	.9	18.5
	7	13.3		17.9	1	16.9	.6	16.3		16.5	.....			19.7	.2	19.5
	6	13.3		17.6	.7	16.9	.5	16.4		16.9	.....			19.9	.3	19.6
	5	13.3		17.7	.9	16.8	.6	16.2		17.4	0.3	17.1		19.3	.2	19.5
	4	13.4		17.8	.7	17.1	.9	16.2		17.6	.2	17.8		18.6	.2	18.8
	3	13.6		17.9	.8	17.1	.8	16.3		18	.3	18.3		18	.5	18.5
	2	13.8		17.8	.7	17.1	.7	16.4		18.2	.4	18.6		18.2	.4	18.6
	1	13.8		17.5	.4	17.1	.7	16.4		18.3	.4	18.7		18.4	.2	18.6
South	1	13.4		17.4	.5	16.9	.7	16.2		18.2	.6	18.8		18.4	.0	18.4
	2	13.3		17.6	.9	16.7	.6	16.1		17.9	.7	18.6		18.1	.8	18.9
	3	13		17.4	.7	16.7	.7	16		17.4	.9	18.3		18.2	.2	19.4
	4	12.9		17.2	.6	16.6	.7	15.9		17.1	.7	17.8		19.4	1.2	19.6
	5	12.8		17.5	.8	16.7	.8	15.9		16.8	.4	17.2		19.9	.1	20
	6	12.7		17.5	.8	16.7	.8	15.9		16.6	.2	16.8		19.7	.1	19.8
	7	12.8		17.5	1.3	16.2	.5	15.7		16.4	.1	16.5		19.2	.2	19.4
	8	12.8		17.7	1.9	15.8	.5	15.3		16.3	.1	16.2		18.8	.2	19
	9	12.8		17.7	1.9	15.8	.8	15		15.9	.0	15.9		18.4	.4	18.8
	10	12.9		17.2	1.7	15.5	.7	14.8		15.4	.2	15.2		18.6	.2	18.8
	11	.....		.....	.....	.....	.....	.....		.....	.....	.....		19	.4	19.4
	12	.....		.....	.....	.....	.....	.....		.....	.....	.....		19.8	.4	20.2
	13	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.4	.0	20.4
	14	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.6	.2	20.4
	15	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.4	.2	20.2
Av. deposit		.....		.....	.94	.....	.73	.....		.....	.29	.....		.....	.06	.....
Annual rate		.....		.....	1.41	.....	.73	.....		.....	.26	.....		.....	.10	.....

Outer division, section 10.

[Oct. and Nov., 1887, average depth before dredging, 9.6. Dredged in Aug., 1889.]

10-foot intervals from axis.		Sept., 1889.		Oct. 5, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 11, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
North	15	.....	Soundings taken June 13, 1890, and showed no perceptible change. Dredged Aug. and Sept., 1891.	.....	.....	.....	.....	.....	Dredged May to Nov., 1893.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	20.3	0.4	19.9
	14	.....		.....	.....	.....	.....	.....		.....	.....			20.2	.5	19.7
	13	.....		.....	.....	.....	.....	.....		.....	.....			19.4	.3	19.1
	12	.....		.....	.....	.....	.....	.....		.....	.....			18.3	.0	18.7
	11	.....		.....	.....	.....	.....	.....		.....	.....			18.1	.1	18
	10	13.1		18	1	17	1.8	15.2		16	.....			18.1	.2	17
	9	13.1		17.8	.3	17.5	1.4	16.1		16.4	.....			18.2	.3	17
	8	13		17.7	.5	17.2	1	16.2		16.5	.....			18.6	.2	17
	7	12.8		17.5	.9	16.6	.7	15.9		16.8	.....			19.1	.2	17
	6	12.8		17.1	.4	16.7	1	15.7		17	.....			19.3	.5	17
	5	12.7		17.2	.3	16.9	.9	16		17.2	0.2	17		19.6	.2	17
	4	12.7		17.6	.7	16.9	.7	16.2		17.3	.5	17.8		19	.2	17
	3	13		17.5	.9	16.6	.5	16.1		17.7	.4	18.1		18.3	.4	17
	2	12.9		17.3	1.1	16.2	.2	16		17.9	.5	18.4		18.2	.2	17
	1	12.8		17.1	.7	16.4	.4	16		18.4	.3	18.7		18.5	.2	17
South	1	12.8		17.2	.7	16.5	.5	16		18.6	.3	18.9		18.6	.2	17
	2	12.8		17.4	1	16.4	.4	16		18.5	.3	18.8		18.2	.4	17
	3	12.9		17.6	1.3	16.3	.5	15.8		18.4	.0	18.4		18.3	.3	17
	4	13		17.6	1.4	16.2	.5	15.7		18	.2	17.8		18.9	.1	17
	5	13		17.5	.9	16.6	.9	15.7		17.2	.0	17.2		19.5	.6	17
	6	13.1		17.5	1	16.5	.8	15.7		17	.3	16.7		19.4	.1	17
	7	13		17	.7	16.3	.8	15.5		16.8	.4	16.4		19.5	.2	17
	8	12.8		16.9	.9	16	.8	15.2		16.6	.7	15.9		18.7	.1	17
	9	12.7		16.9	1.2	15.7	.9	14.8		16.2	.6	15.6		18.5	.2	17
	10	12.8		16.9	1.4	15.5	1.2	14.3		15.5	.5	15		18.4	.2	17
	11	.....		.....	.....	.....	.....	.....		.....	.....	.....		19	.2	17
	12	.....		.....	.....	.....	.....	.....		.....	.....	.....		19.6	.2	17
	13	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.2	.2	17
	14	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.5	.2	17
	15	.....		.....	.....	.....	.....	.....		.....	.....	.....		20.4	.2	17
Av. deposit		.....		.....	.86	.....	.80	.....		.....	.04	.....		.....	.....	.....
Annual rate		.....		.....	1.29	.....	.80	.....		.....	.04	.....		.....	.....	.....

Outer division, section 15.

[Oct. and Nov., 1887, average depth before dredging, 11.7. Dredged in July and Aug., 1891.]

t inter- s from axis.	Aug., 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
th 15											19.2	0.0	19.2
14											20.4	.9	19.5
13											20.4	.9	19.5
12											20.1	.8	19.3
11											19.6	.7	18.9
10	17.4	1.9	15.5	0.4	15.1		15.7				19.2	.8	18.4
9	17.5	1.2	16.3	1.1	15.2		16.1				19.1	.7	18.4
8	17.1	.8	16.3	1.1	15.2		16.6				19.0	.1	18.9
7	17.1	.8	16.3	1.0	15.3		17.0				19.7	.4	19.3
6	17.1	.9	16.2	.8	15.4		17.2				20.1	.7	19.4
5	17.0	.9	16.1	.7	15.4		17.5	0.4	17.1		19.8	.6	19.2
4	16.8	.7	16.1	.6	15.5		17.8	— .2	18.0		19.1	.5	18.6
3	16.8	.6	16.2	.6	15.6		18.1	— .1	18.2		18.6	.5	18.1
2	16.9	.7	16.2	.7	15.5		18.4	— .1	18.5		18.7	.4	18.3
1	16.5	.6	15.9	.3	15.6		18.5	— .2	18.7		18.8	.3	18.5
uth 1	16.5	.7	15.8	.3	15.5		18.4	— .3	18.7		18.8	.4	18.4
2	16.5	.6	15.9	.5	15.4		18.1	— .6	18.7		18.6	.3	18.3
3	16.5	.6	15.9	.6	15.3		17.8	— .8	18.6		18.5	.2	18.3
4	16.5	.7	15.8	.5	15.3		17.6	— .7	18.3		19.3	.6	18.7
5	16.3	.3	16.0	.8	15.2		17.2	— .6	17.8		20.0	.8	19.2
6	16.4	.4	16.0	1.0	15.0		16.9	— .4	17.3		19.9	.6	19.3
7	16.3	.4	15.9	1.0	14.9		16.6	— .2	16.8		19.1	.0	19.1
8	16.4	.8	15.6	.8	14.8		16.4	— .3	16.7		18.2	.0	18.2
9	16.6	1.3	15.3	.7	14.6		16.2	— .4	16.6		18.0	.4	17.6
10	16.1	1.2	14.9	.5	14.4		15.8	— .8	16.6		18.6	.4	18.2
11											18.9	.5	18.4
12											19.2	.8	18.4
13											19.6	1.2	18.4
14											19.7	1.3	18.4
15											19.1	.9	18.2
Av. deposit		.80		.70				— .35				.56	
Annual rate		.96		.70				— .35				.96	

Dredged May to Nov., 1893. Dredging in progress. Widened and deepened, 1897.

Outer division, section 16.

[Oct. and Nov., 1887, average depth before dredging, 12.6. Dredged Aug., Sept., and Oct., 1891.]

10-foot intervals from axis.	Oct. 6, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15											19.9	0.4	19.5
14											20.4	.8	19.6
13											20.3	.7	19.6
12											20	.8	19.2
11											19.6	.8	18.8
10	17.3	1.2	16.1	0.6	15.5		15.8				19.2	.7	18.5
9	17.4	1.1	16.3	.7	15.6		16.4				19.2	.7	18.5
8	17.6	1.1	16.5	.8	15.7		16.8				19.6	.5	19.1
7	17.5	1	16.5	.9	15.6		17.2				20	.4	19.6
6	17	.5	16.5	.9	15.6		17.4				20	.7	19.3
5	16.9	.5	16.4	.6	15.8		17.7	0.1	17.6		19.7	.9	18.8
4	17.2	.9	16.3	.5	15.8		18	— .1	18.1		18.5	.3	18.2
3	17.1	.7	16.4	.7	15.7		18.1	— .3	18.4		18.5	.4	18.1
2	17.1	.6	16.5	.7	15.8		18.4	— .1	18.5		18.7	.4	18.3
1	17.5	1	16.5	.7	15.8		18.4	— .3	18.7		18.7	.3	18.4
South 1	17.4	.9	16.5	.7	15.8		18.4	— .4	18.8		18.6	.2	18.4
2	17.2	.7	16.5	.7	15.8		18.2	— .6	18.8		18.5	.1	18.4
3	17	.6	16.4	.7	15.7		17.8	— .8	18.6		18.5	.2	18.3
4	17	.9	16.1	.4	15.7		17.6	— .7	18.3		19.9	.8	19.1
5	17.1	1.1	16	.5	15.5		17.3	— .7	18		20.2	.6	19.6
6	17	.8	16.2	.8	15.4		17	— .6	17.6		20.3	.7	19.6
7	17	.9	16.1	.6	15.5		16.8	— .4	17.2		20.2	.9	19.3
8	16.5	.5	16	.6	15.4		16.6	— .2	16.8		19	— .2	19.2
9	16.6	.7	15.9	.5	15.4		16.5	— .3	16.8		18.6	— .3	18.9
10	17	1.3	15.7	.4	15.3		16.1	— .1	16.2		18.9	.0	18.9
11											19.5	.3	19.2
12											19.9	.5	19.4
											20.1	.7	19.4
											20.2	.7	19.5
											20	.5	19.5
		.85		.65				— .36				.48	
		1.27		.65				— .36				.82	

Dredged May to Nov., 1893. Dredging in progress. Widened and deepened, 1897.

Outer division, section 13.

[Oct. and Nov., 1887, average depth before dredging, 8.2. Dredged in Aug., 1889.]

10-foot intervals from axis.	Sept., 1889.		July 22, 1891.		Oct. 21, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 27, 1896.	Deposit.	June, 1897.		Oct. 1897.	Deposit.	May 13, 1898.
North 15		Soundings taken June 13, 1890, and showed no perceptible change.		Dredged in Oct., 1891.						Dredged May to Nov., 1893.			Dredging in progress.	Widened and deepened, 1897.	19.6	0.3	19.
14															19.9	1.3	19.
13															19.8	.7	19.
12															19.4	.6	18.
11															19.0	.4	18.
10	12.5		11.2		15.9	3.8	12.1	—1.0	13.1		16.8				18.4	.0	18.
9	12.8		11.8		16.7	.1	16.6	1.9	14.7		17.0				18.2	— .2	18.
8	12.7		12.1		16.7	.2	16.5	.9	15.6		17.2				19.1	.5	18.
7	12.4		12.1		16.7	— .1	16.8	.9	15.9		17.4				20.2	1.2	19.
6	12.4		12.3		16.6	.0	16.6	.6	16.0		17.9				20.3	.6	19.
5	12.4		12.2		16.4	— .1	16.5	.5	16.0		18.3	0.4	17.9		20.0	.6	19.
4	12.4		12.3		16.1	— .1	16.2	.3	15.9		18.4	— .1	18.3		19.2	.2	19.
3	12.5		12.3		16.3	.2	16.1	.1	16.0		18.5	— .1	18.6		18.7	.1	18.
2	12.5		12.5		16.4	.1	16.3	.3	16.0		18.4	— .4	18.8		18.7	.1	18.
1	12.5		12.3		16.2	— .2	16.4	.3	16.1		18.6	— .4	19.0		18.8	.1	18.
South 1	12.4		12.4		16.2	.0	16.2	.2	16.0		18.7	— .3	19.0		18.8	.0	18.
2	12.6		12.5		16.3	.0	16.3	.6	15.7		18.7	— .3	19.0		18.6	— .2	18.
3	12.7		12.5		16.2	— .2	16.4	.7	15.7		18.5	— .3	18.8		18.3	— .4	18.
4	12.6		12.4		16.0	— .3	16.3	.7	15.6		18.0	— .2	18.2		18.8	— .2	19.
5	12.5		12.4		16.1	.3	15.8	.5	15.3		17.4	— .4	17.8		19.8	.3	19.
6	12.6		12.1		15.9	.5	15.4	.4	15.0		17.3	— .1	17.4		20.0	.2	19.
7	12.7		11.9		15.8	1.0	14.8	.5	14.3		17.3	.2	17.1		19.9	.5	19.
8	12.4		11.5		15.5	1.9	13.6	.2	13.4		17.1	.5	16.6		19.0	.1	18.
9	11.8		11.4		14.1	2.3	11.8	— .4	12.2		17.0	.9	16.1		18.1	— .1	18.
10	11.3		10.5		12.2	1.0	11.2	— .2	11.4		16.3	1.6	14.7		18.0	.0	18.
11															18.7	.4	18.
12															18.8	.0	18.
13															19.4	.4	19.
14															19.8	1.1	18.
15															19.7	1.7	18.
Av. deposit.						.52		.40				.08				.31	
Annual rate						.83		.40				.07				.53	

Outer division, section 14.

[Oct. and Nov., 1887, average depth before dredging, 10.1. Dredged in Sept., 1889.]

10-foot intervals from axis.	Sept., 1889.		July 22, 1891.		Oct. 21, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		May 27, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
North 15		Soundings June 13, 1890, showed no perceptible change.		Dredged July, Aug., and Sept., 1891.						Dredged May to Nov., 1893.			Dredging in progress.	Widened and deepened, 1897.	19.5	0.1	19.
14															20.2	.6	19.
13															20.1	.7	19.
12															19.9	.8	19.
11															19.3	.5	18.
10	13.0		11.7		17.1	1.0	16.1	0.8	15.3		16.8				19.1	.5	18.
9	13.0		11.7		16.9	.5	16.4	1.0	15.4		17.2				19.0	.5	18.
8	12.6		11.9		16.6	.2	16.4	.9	15.5		17.4				19.9	.9	19.
7	12.2		11.8		16.8	.4	16.4	.8	15.6		17.6				20.3	.8	19.
6	12.5		11.9		16.8	.4	16.4	.7	15.7		17.7				20.2	.6	19.
5	12.2		11.9		16.4	.0	16.4	.7	15.7		18.3	1.4	16.9		19.8	.4	19.
4	12.3		12.1		16.3	— .1	16.4	.5	15.9		18.6	.6	18.0		19.2	.6	18.
3	12.7		12.1		16.7	.5	16.2	.3	15.9		18.7	.2	18.5		18.7	.4	18.
2	12.5		12.1		16.7	.5	16.2	.3	15.9		18.8	.0	18.8		18.8	.4	18.
1	12.5		12.0		16.4	.2	16.2	.3	15.9		18.9	— .1	19.0		18.9	.5	18.
South 1	12.8		12.1		16.5	.2	16.3	.4	15.9		19.0	.0	19.0		18.9	.5	18.
2	12.5		12.0		16.7	.3	16.4	.5	15.9		18.8	— .2	19.0		18.6	.2	18.
3	12.2		12.1		16.8	.3	16.5	.7	15.8		18.3	— .5	18.8		18.1	.1	18.
4	12.4		12.0		17.1	.6	16.5	.7	15.8		17.8	— .4	18.2		18.9	.6	18.
5	13.7		12.1		17.4	1.0	16.4	.7	15.7		17.6	— .2	17.8		19.3	.1	18.
6	12.8		12.0		17.3	.9	16.4	.8	15.6		17.3	— .2	17.5		19.9	.5	19.
7	13.9		12.0		17.1	.8	16.3	.9	15.4		17.1	— .2	17.3		20.1	.7	19.
8	13.2		11.9		16.9	.8	16.1	.9	15.2		16.7	.0	16.7		19.7	.4	19.
9	13.0		11.8		16.8	1.1	15.7	1.1	14.6		16.5	.3	16.2		18.4	.5	17.
10	12.8		11.7		16.7	1.7	15.0	1.0	14.0		15.9	.2	15.7		18.1	.5	17.
11															18.6	.8	17.
12															19.3	.6	18.
13															19.7	.7	19.
14															19.9	.9	19.
15															19.7	1.1	18.
Av. deposit.						.56		.70				.09				.55	
Annual rate						.92		.70				.08				.94	

Outer division, section 15.

[Oct. and Nov., 1887, average depth before dredging, 11.7. Dredged in July and Aug., 1891.]

10-foot intervals from axis.	Aug., 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15						Dredged May to Nov., 1893.			Dredging in progress.	Widened and deepened, 1897.	19.2	0.0	19.2
14											20.4	.9	19.5
13											20.4	.9	19.5
12											20.1	.8	19.3
11											19.6	.7	18.9
10	17.4	1.9	15.5	0.4	15.1		15.7				19.2	.8	18.4
9	17.5	1.2	16.3	1.1	15.2		16.1				19.1	.7	18.4
8	17.1	.8	16.3	1.1	15.2		16.6				19.0	.1	18.9
7	17.1	.8	16.3	1.0	15.3		17.0				19.7	.4	19.3
6	17.1	.9	16.2	.8	15.4		17.2				20.1	.7	19.4
5	17.0	.9	16.1	.7	15.4		17.5	0.4	17.1		19.8	.6	19.2
4	16.8	.7	16.1	.6	15.5		17.8	.2	18.0		19.1	.5	18.6
3	16.8	.6	16.2	.6	15.6		18.1	.1	18.2		18.6	.5	18.1
2	16.9	.7	16.2	.7	15.5		18.4	.1	18.5		18.7	.4	18.3
1	16.5	.6	15.9	.3	15.6		18.5	.2	18.7		18.8	.3	18.5
South 1	16.5	.7	15.8	.3	15.5		18.4	.3	18.7		18.8	.4	18.4
2	16.5	.6	15.9	.5	15.4		18.1	.6	18.7		18.6	.3	18.3
3	16.5	.6	15.9	.6	15.3		17.8	.8	18.6		18.5	.2	18.3
4	16.5	.7	15.8	.5	15.3		17.6	.7	18.3		19.3	.6	18.7
5	16.3	.3	16.0	.8	15.2		17.2	.6	17.8		20.0	.8	19.2
6	16.4	.4	16.0	1.0	15.0		16.9	.4	17.3		19.9	.6	19.3
7	16.3	.4	15.9	1.0	14.9		16.6	.2	16.8		19.1	.0	19.1
8	16.4	.8	15.6	.8	14.8		16.4	.3	16.7		18.2	.0	18.2
9	16.6	1.3	15.3	.7	14.6		16.2	.4	16.6		18.0	.4	17.6
10	16.1	1.2	14.9	.5	14.4		15.8	.8	16.6		18.6	.4	18.2
11											18.9	.5	18.4
12											19.2	.8	18.4
13											19.6	1.2	18.4
14											19.7	1.3	18.4
15											19.1	.9	18.2
Av. deposit		.80		.70				.35				.56	
Annual rate		.96		.70				.35				.96	

Outer division, section 16.

[Oct. and Nov., 1887, average depth before dredging, 12.6. Dredged Aug., Sept., and Oct., 1891.]

10-foot intervals from axis.	Oct. 6, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15						Dredged May to Nov., 1893.			Dredging in progress.	Widened and deepened, 1897.	19.9	0.4	19.5
14											20.4	.8	19.6
13											20.3	.7	19.6
12											20	.8	19.2
11											19.6	.8	18.8
10	17.3	1.2	16.1	0.6	15.5		15.8				19.2	.7	18.5
9	17.4	1.1	16.3	.7	15.6		16.4				19.2	.7	18.5
8	17.6	1.1	16.5	.8	15.7		16.8				19.6	.5	19.1
7	17.5	1	16.5	.9	15.6		17.2				20	.4	19.6
6	17	.5	16.5	.9	15.6		17.4				20	.7	19.3
5	16.9	.5	16.4	.6	15.8		17.7	0.1	17.6		19.7	.9	18.8
4	17.2	.9	16.3	.5	15.8		18	.1	18.1		18.5	.3	18.2
3	17.1	.7	16.4	.7	15.7		18.1	.3	18.4		18.5	.4	18.1
2	17.1	.6	16.5	.7	15.8		18.4	.1	18.5		18.7	.4	18.3
1	17.5	1	16.5	.7	15.8		18.4	.3	18.7		18.7	.3	18.4
South 1	17.4	.9	16.5	.7	15.8		18.4	.4	18.8		18.6	.2	18.4
2	17.2	.7	16.5	.7	15.8		18.2	.6	18.8		18.5	.1	18.4
3	17	.6	16.4	.7	15.7		17.8	.8	18.6		18.5	.2	18.3
4	17	.9	16.1	.4	15.7		17.6	.7	18.3		19.9	.8	19.1
5	17.1	1.1	16	.5	15.5		17.3	.7	18		20.2	.6	19.6
6	17	.8	16.2	.8	15.4		17	.6	17.6		20.3	.7	19.6
7	17	.9	16.1	.6	15.5		16.8	.4	17.2		20.2	.9	19.3
8	16.5	.5	16	.6	15.4		16.6	.2	16.8		19	.2	19.2
9	16.6	.7	15.9	.5	15.4		16.5	.3	16.8		18.6	.3	18.9
10	17	1.3	15.7	.4	15.3		16.1	.1	16.2		18.9	.0	18.9
11											19.5	.3	19.2
12											19.9	.5	19.4
13											20.1	.7	19.4
14											20.2	.7	19.5
15											20	.5	19.5
Av. deposit		.85		.65				.36				.48	
Annual rate		1.27		.65				.36				.52	

Outer division, section 17.

[Oct. and Nov., 1887. Average depth before dredging, 13.6. Dredged in Aug. and Sept., 1891.]

10-foot intervals from axis.	Oct. 6, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
North 15						Dredged May to Nov., 1893.			Dredging in progress.	Widened and deepened, 1897.	18.9	0.1	18.8
14											19.7	.8	18.9
13											19.7	.7	19
12											19.7	1.1	18.6
11											19.4	.6	18.8
10	17.6	1.2	16.4	0.7	15.7		16.4				19.3	.7	18.6
9	17.8	1.1	16.7	.9	15.8		16.7				19.3	.9	18.4
8	17.7	.9	16.8	1.0	15.8		16.9				19.6	1	18.6
7	17.5	.8	16.7	.9	15.8		17.2				19.8	.8	19
6	17.3	.7	16.6	.8	15.8		17.5				20.1	1	19.1
5	17.1	.4	16.7	.9	15.8		17.8	0.4	18.2		19.9	.8	19.1
4	17.2	.5	16.7	.8	15.9		18.2	.5	18.7		18.5	.1	18.6
3	17.3	.6	16.7	.8	15.9		18.4	.4	18.8		18.5	.2	18.3
2	17.6	.9	16.7	.8	15.9		18.4	.5	18.9		18.7	.4	18.3
1	17.4	.7	16.7	.7	16		18.6	.3	18.9		18.7	.2	18.5
South 1	17.5	.9	16.6	.6	16		18.4	.4	18.8		18.6	.1	18.5
2	17.4	.8	16.6	.6	16		18.2	.5	18.7		18.7	.3	18.4
3	17.1	.5	16.6	.6	16		18.1	.5	18.6		19.3	.7	18.6
4	17	.4	16.6	.6	16		17.8	.5	18.3		19.8	.7	19.1
5	17.1	.6	16.5	.6	15.9		17.5	.5	18		20.1	.6	19.5
6	17.1	.7	16.4	.5	15.9		17.2	.6	17.8		20.3	.6	19.7
7	16.9	.6	16.3	.5	15.8		17	.5	17.5		20	.5	19.1
8	17.1	.8	16.3	.6	15.7		16.8	.4	17.2		19.2	.3	18.9
9	17.1	1	16.1	.5	15.6		16.7	.3	17		20	1.5	18.5
10	16.7	1	15.7	.2	15.5		16.4	.4	16.8		20	.9	19.1
11											20.2	.8	19.4
12											20.2	.8	19.4
13											20.3	1	19.3
14											20.4	1.1	19.3
15											19.3	.2	19.1
Av. deposit		.75		.68				.45				.64	..
Annual rate		1.12		.68				.45				1.09	.....

Outer division, section 18.

[Oct. and Nov., 1887, average depth before dredging, 14.2. Dredged in Sept., 1891.]

10-foot intervals from axis.	Oct. 6, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 13, 1898.
North 15						Dredged May to Nov., 1893.				Widened and deepened, 1897.	19.4	0.4	19
14											20.1	1	19.1
13											20.1	1	19.1
12											19.8	1	18.8
11											19.6	.8	18.8
10	16.3	0.2	16.1	0.2	15.9		17	0.6	17.6		19.6	1.2	18.4
9	16.8	.4	16.4	.5	15.9		17.5	.3	17.8		19.3	1.5	17.8
8	17.1	.5	16.6	.6	16		17.6	.4	18		18.3	.7	17.6
7	17.2	.4	16.8	.8	16		17.8	.5	18.3		18	.3	17.7
6	17.2	.4	16.8	.8	16		17.9	.8	18.7		18.3	.3	18
5	17.1	.3	16.8	.7	16.1		18.1	.8	18.9		18.5	.2	18.3
4	17.1	.3	16.8	.7	16.1		18.6	.5	19.1		18.6	.0	18.6
3	17.3	.5	16.8	.7	16.1		18.8	.5	19.3		18.7	.0	18.7
2	17.3	.5	16.8	.7	16.1		18.9	.5	19.4		18.8	.1	18.7
1	17.2	.3	16.9	.8	16.1		19	.4	19.4		18.9	.1	18.8
South 1	17.2	.5	16.7	.6	16.1		18.9	.5	19.4		18.9	.3	18.6
2	17.3	.7	16.6	.5	16.1		18.6	.5	19.1		18.7	.3	18.4
3	17.3	.7	16.6	.5	16.1		18.5	.5	19		18.7	.2	18.9
4	17.2	.5	16.7	.6	16.1		18.3	.5	18.8		19.5	.1	19.4
5	17.1	.5	16.6	.5	16.1		18.1	.5	18.6		20	.5	19.5
6	17	.5	16.5	.5	16		17.9	.4	18.3		20	.6	19.4
7	17	.5	16.5	.5	16		17.5	.4	17.9		19.9	1.1	18.8
8	17	.6	16.4	.5	15.9		17.4	.4	17.8		19.3	.7	18.6
9	17	.6	16.4	.5	15.9		17.2	.4	17.6		18.9	.2	18.7
10	16.9	.7	16.2	.4	15.8		16.9	.4	17.3		19.1	.2	18.9
11											19.7	.5	19.2
12											20.1	.7	19.4
13											20.4	1.1	19.3
14											20.4	1.3	19.1
15											20	1.5	18.5
Av. deposit		.48		.58				.49				.58	.....
Annual rate		.72		.58				.49				.99	.....

Outer division, section 19.

[Oct. and Nov., 1887, average depth before dredging, 15.3. Dredged Sept., Oct., and Nov., 1891.]

10-foot intervals from axis.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15	.....	.....	.....	Dredged in spring, 1894.	.....	.....	.....	Widened and deepened, 1897.	19.9	1.4	18.5
14	.....	.....	.....		.....	.....	.....		20.4	1.4	19
13	.....	.....	.....		.....	.....	.....		20.4	1.3	19.1
12	.....	.....	.....		.....	.....	.....		20.1	1	19.1
11	.....	.....	.....		.....	.....	.....		19.5	.4	19.1
10	15.9	0.0	15.9		17.2	—1.2	18.4		19.5	.5	19
9	16	.0	16		18.2	—.8	19		18.9	.2	18.7
8	16.1	.0	16.1		18.4	—.8	19.2		18.9	.4	18.5
7	16.1	.0	16.1		18.8	—.7	19.5		18.2	.0	18.2
6	16.1	—.1	16.2		19	—.6	19.6		18.7	.3	18.4
5	16.4	.2	16.2		19.2	—.2	19.4		18.8	.1	18.7
4	16.7	.5	16.2		19.2	—.3	19.5		18.9	.2	18.7
3	16.9	.6	16.3		19.2	—.6	19.8		19.2	.4	18.8
2	17.1	.8	16.3		19.3	—.4	19.7		19.2	.3	18.9
1	17	.7	16.3		19.3	—.5	19.8		19.3	.4	18.9
South 1	16.9	.6	16.3		19.3	—.5	19.8		19.1	.2	18.9
2	16.9	.6	16.3		19.2	—.6	19.8		19	.1	18.9
3	16.5	.3	16.2		19.2	—.5	19.7		18.9	.1	18.8
4	16	—.2	16.2		19.1	—.5	19.6		18.9	.3	18.6
5	15.9	—.2	16.1		18.8	—.6	19.4		18.6	.4	18.2
6	16	—.1	16.1		18.7	—.4	19.1		18.4	.3	18.1
7	16	.0	16		18.8	—.0	18.8		18.6	.3	18.3
8	16	.1	15.9		18.6	—.0	18.6		19.4	.3	19.1
9	15.9	.0	15.9		18.4	—.1	18.5		19.9	.5	19.4
10	15.8	.0	15.8		17.9	—.1	17.8		19.9	.4	19.5
11	.....	.....	.....		.....	.....	.....		20.2	.6	19.6
12	.....	.....	.....		.....	.....	.....		20.3	.7	19.6
13	.....	.....	.....		.....	.....	.....		20.5	1	19.5
14	.....	.....	.....		.....	.....	.....		20.6	1.2	19.4
15	.....	.....	.....		.....	.....	.....		19.5	.6	18.9
Av. deposit	.....	.18	.....	.....	.....	—.46	.....	.....	.....	.51	.....
Annual rate	.....	.18	.....	.....	.....	—.46	.....	.....	.....	.87	.....

Outer division, section 20.

[Oct. and Nov., 1887, average depth before dredging, 16. Dredged in Oct., 1891.]

8-foot intervals from axis.	Nov. 4, 1891.	Deposit.	May and June, 1892.	Deposit.	May, 1893.		June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15	.....	.....	.....	.....	.....	Dredged in spring, 1894.	.....	.....	Dredging in progress.	Widened and deepened, 1897.	20.2	1.5	18.7
14	.....	.....	.....	.....	.....		.....	.....			20.4	1.1	19.3
13	.....	.....	.....	.....	.....		.....	.....			20.5	1.1	19.4
12	.....	.....	.....	.....	.....		.....	.....			20.5	1	19.5
11	.....	.....	.....	.....	.....		.....	.....			20.5	1.2	19.3
10	16.2	0.0	16.2	—.1	16.3		16.9	.....			19.9	1.1	18.8
9	16.2	—.1	16.3	.1	16.2		18	.....			19.2	.6	18.6
8	16.3	.0	16.3	.0	16.3		18.4	.....			18.7	.7	18
7	16.4	.1	16.3	.0	16.3		18.5	.....			18.6	.2	18.4
6	16.4	—.1	16.3	—.1	16.4		18.5	.....			18.7	.1	18.6
5	16.4	.1	16.3	—.1	16.4		18.8	—.2	19		19	.4	18.6
4	16.4	.1	16.3	—.1	16.4		19	—.3	19.3		19.1	.4	18.7
3	16.4	.1	16.3	—.1	16.4		19	—.4	19.4		19.2	.4	18.8
2	16.4	.2	16.3	—.2	16.4		19	—.5	19.5		19.3	.4	18.9
1	16.5	.3	16.2	—.2	16.4		19	—.6	19.6		19.4	.4	19
South 1	16.2	.0	16.2	—.2	16.4		19	—.6	19.6		19.3	.5	18.8
2	16.3	.1	16.2	—.2	16.4		19.2	—.5	19.7		19.3	.6	18.7
3	16.4	.2	16.2	—.2	16.4		19.2	—.4	19.6		19.2	.5	18.7
4	16.6	.4	16.2	—.1	16.3		19.2	—.4	19.6		19	.5	18.5
5	16.5	.3	16.2	—.1	16.3		19.2	—.4	19.6		18.8	.3	18.5
6	16.4	.2	16.2	.0	16.2		19	—.5	19.5		18.7	.4	18.3
7	16.3	.1	16.2	—.1	16.3		19	—.4	19.4		18.6	.2	18.4
8	16.3	.2	16.1	—.2	16.3		19	—.4	19.4		19.6	.7	18.9
9	16.4	.3	16.1	—.1	16.2		19	—.3	19.3		20.5	1.1	19.4
10	16.2	.1	16.1	—.1	16.2		18.8	—.3	19.1		20.6	1.1	19.5
11	.....	.....	.....	.....	.....		.....	.....	.....		20.7	1.1	19.6
12	.....	.....	.....	.....	.....		.....	.....	.....		20.9	1.2	19.7
13	.....	.....	.....	.....	.....		.....	.....	.....		21.1	1.3	19.8
14	.....	.....	.....	.....	.....		.....	.....	.....		21.1	1.5	19.6
15	.....	.....	.....	.....	.....		.....	.....	.....		20.4	1.2	19.2
Av. deposit	.....	.14	.....	—.10	.....	.....	.....	—.41	.....	.....	.....	.76	.....
Annual rate	.....	.24	.....	—.10	.....	.....	.....	—.41	.....	.....	.....	1.30	.....

Outer division, section 21.

[Oct. and Nov., 1887, average depth before dredging, 17.1. Dredged in spring, 1894.]

10-foot intervals from axis.	June 8, 1896.	Deposit.	June, 1897.		Oct., 1897.	Deposit.	May 12, 1898.
North 15					20.7	0.7	
14					20.8	.6	
13					20.2	.1	
12					20.1	.1	
11					20	.1	
10	18.3	—0.5	18.8		20.2	.3	
9	19.5	— .5	20		20.1	.6	
8	19.8	— .2	20		19.7	.6	
7	19.9	— .3	20.2		19.5	.1	
6	19.9	— .3	20.2		19.5	.1	
5	19.8	— .4	20.2		19.7	.2	
4	19.8	— .4	20.2		19.8	.2	
3	19.8	— .4	20.2		19.9	.2	
2	19.8	— .4	20.2		20	.3	
1	19.8	— .2	20		20	.3	
South 1	19.7	— .2	19.9	Widened and deepened, 1897.	19.9	.3	
2	19.6	— .2	19.8		19.8	.2	
3	19.5	— .3	19.8		19.7	.1	
4	19.2	— .6	19.8		19.6	.2	
5	19.2	— .5	19.7		19.5	.4	
6	19.3	— .3	19.6		19.3	.1	
7	19.1	— .3	19.4		19.3	.2	
8	19	— .2	19.2		19.7	.0	
9	19	.0	19		20.6	.5	
10	19	.2	18.8		20.5	.3	
11					20.3	.0	
12					20.2	— .1	
13					20.7	.4	
14					20.9	.6	
15					20.8	1	
Average deposit		— .30				.29	
Annual rate		— .80				.50	

Outer division, section 22.

[Never dredged.]

10-foot intervals from axis.	June, 1896.	Deposit.	May 12, 1898.	10-foot intervals from axis.	June, 1896.	Deposit.	May 18
North 15			17.9	South 3	17.8	— .4	
14			17.9	4	17.8	— .3	
13			17.9	5	17.8	— .4	
12			17.9	6	17.8	— .4	
11			18	7	17.8	— .4	
10	17.7	—0.3	18	8	17.7	— .4	
9	17.7	— .4	18.1	9	17.6	— .4	
8	17.7	— .4	18.1	10	17.6	— .4	
7	17.8	— .3	18.1	11			
6	17.8	— .4	18.2	12			
5	17.8	— .5	18.3	13			
4	17.8	— .5	18.3	14			
3	17.8	— .5	18.3	15			
2	17.8	— .4	18.2				
1	17.8	— .5	18.3	Average deposit		— .40	
South 1	17.8	— .4	18.2	Annual rate		— .21	
2	17.8	— .4	18.2				

Eng 55 3

ry of average annual rates of deposit during different periods.

INNER DIVISION (GRAND AVERAGE, 0.45).

	Section numbers.															General average.
	15.	14.	13.	12.	11.	10.	9.	8.	7.	6.	5.	4.	3.	2.	1.	
92	0.14	0.28	0.49	0.86	0.82	0.73	0.64	0.54	0.33	0.47	0.59	0.55	0.74	0.42	0.49	0.54
.....	.....	.....	1.03	—.07	—.43	—.28	.14	.48	.68	.49	.68	.44	.40	.45	.28	.33
.....	.62	.55	1.03	.41	.31	.56	.64	.71	.30	.08	.29	.25	.30	.32	.57	.46
.....	—.08	.05	.07	.42	.36	.15	.36	.52	.51	.41	.24	.07	.12	.38	.24	.25
97....	.87	.84	.96	.78	.48	.12	.12	.12	.33	.57	.36	.54	.24	—.06	.18	.43
98	.12	.26	.48	.53	.60	1.23	.89	.67	1.01	.69	.69	.75	.75	.82	.72	.68
ges ...	.33	.40	.68	.49	.36	.42	.46	.51	.53	.45	.48	.43	.42	.40	.41	.45

MIDDLE DIIVISON (GRAND AVERAGE, 0.43).

1.	Section numbers.													General average.
	15.	14.	13.	12.	11.	10.	9.	8.	7.	6.	5.	4.	3.	
92	0.37	0.51	1	0.75	0.67	0.25	0.37	0.38	0.43	0.45	0.48	0.54	0.53	0.52
.....	.....	.30	.00	.04	.62	.72	.48	.40	.38	.56	.66	.54	.60	.44
.....	.....	.42	.25	.16	.08	.13	.03	.07	.21	.22	.18	.17	.25	.18
.....	.38	.36	.31	.68	.59	.46	.56	.40	.31	.38	.46	.43	.38	.44
97.....	.18	—.21	—.30	—.57	.36	.12	—.18	.81	.96	.96	.81	.66	.60	.32
98	.77	.93	.87	.87	.51	.82	1.17	.84	.45	.55	.51	.38	.58	.67
ges	.42	.38	.36	.32	.47	.42	.40	.40	.46	.52	.52	.45	.49	.43

OUTER DIVISION (GRAND AVERAGE, 0.48).

Section numbers.																General average.
5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
1.37	1.03	0.40	0.42	1.41	1.29	1.28	.92	.83	.92	0.96	1.27	1.12	0.72	.....	0.24	0.98
.54	.74	.67	.80	.73	.80	.53	.63	.40	.70	.70	.65	.68	.58	.18	—.10	.51
.21	.14	.20	—.09	—.26	.04	.01	.07	.07	.08	—.35	—.36	—.45	—.49	—.46	—.41	—.10
.02	.17	—.02	—.21	—.10	.02	.00	.19	.53	.94	.96	.82	1.09	.99	.87	1.30	.47
.54	.52	.31	.23	.44	.54	.46	.45	.46	.66	.57	.60	.61	.45	.20	.26	.48

M M 3.

'ROVEMENT OF PORT CLINTON HARBOR, OHIO.

: is in and near the mouth of the Portage River, which e Erie at a point about 13 miles west of Sandusky by the oute and 22 miles by the way of Sandusky Bay and Lake er is navigable for small vessels as far from its mouth as The natural conditions usually afforded about 5 feet r at the mouth and somewhat more inside.

risions of the river and harbor acts of 1867 and 1870, were made and reports submitted with reference to e harbor. In 1873 a narrow channel 8 feet deep was the river to same depth in the lake, and in 1874 a sand lt across the point north of the mouth of the river.

In 1875 a plan was adopted to protect the channel over the bar by a construction of piles and waling pieces, to which was secured a sheet piling of oak plank. These constructions on each side of the channel were terminated at the lake ends by stronger works of timber cribs upon substructures of close piling filled with stone. On the east side the pierhead is but about 14 feet square, but on the west side there is a length of 720 feet 14 feet in width.

Total estimated cost	$90,000.00
Total expenditures to June 30, 1898, including $1,200 paid for part of sand point	80,284.87
Unexpended July 1, 1898	7,715.13

Nearly one-half of the unexpended balance is due for liabilities incurred previous to July 1.

There is now a good channel 100 feet wide and 10 feet deep between the piers and 200 feet wide with same depth inside.

The drifting of sand has been entirely checked by the sand fence and subsequent growth of trees and other vegetation, and the channel depths, since dredging in the clay bottom, have been maintained by natural conditions. The old woodwork above water is in a very rotten and dilapidated condition.

At the end of the last fiscal year a contract had been executed for repairs and reenforcing the piers and piling by putting against it, upon both sides, a riprap slope of stone, and to pave the top of wide part of west pier as far as available funds permit.

The commencement of the work was delayed until October 18, 1897, but has been pushed forward since that time, except when necessarily suspended for the winter. The amount of stone placed in and against the piers to June 30, 1898, is, paving stone, 56.8 tons; slope stone, 34,437 tons; core stone, 4,588.1 tons.

As a small balance of funds remains available for further work, the time of completion of contract has been extended to July 31, 1898. The completion of work under this contract will leave the piers throughout most of their length in such condition that they will withstand any probable forces of the sea and ice for a long time, and the balance of funds estimated to complete the original project will be sufficient to put the piers in a practically permanent condition.

The necessities of commerce at Port Clinton are not great. There are some passenger steamers and a few vessels carrying freights of local importance only, and several tugs and other small vessels are engaged in fisheries.

Port Clinton is a port of entry in the collection district of Sandusky, Ohio. The nearest light is the one recently established on outer end of west pier.

Money statement.

July 1, 1897, balance unexpended		$12,153.58
June 30, 1898, amount expended during fiscal year		4,438.35
July 1, 1898, balance unexpended		7,715.13
July 1, 1898, outstanding liabilities	$3,756.40	
July 1, 1898, amount covered by uncompleted contracts	2,785.96	
		6,546.36
July 1, 1898, balance available		1,172.77
Amount (estimated) required for completion of existing project		15,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		15,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

List of appropriations for improving harbor of Port Clinton, Ohio.

10, 1872	$8,000.00	August 11, 1888	$5,000.00
10, 1872 (allotment)	2,000.00	September 19, 1890	3,000.00
3, 1875	5,000.00	July 13, 1892	10,000.00
st 14, 1876	5,000.00	August 18, 1894	6,000.00
18, 1878	10,000.00	June 3, 1896	6,000.00
3, 1879	10,000.00	Total	88,000.00
14, 1880	5,000.00	Expended to June 30, 1898	80,284.87
3, 1881	5,000.00		
st 2, 1882	6,000.00	Unexpended July 1, 1898	7,715.13
st 5, 1886	2,000.00		

f contracts for improving harbor of Port Clinton, Ohio, in force during the fiscal year ending June 30, 1898.

Contract for reenforcing with stone the jetties at entrance to Port Clinton Harbor, Ohio.]

ie of contractor, John Stang, Lorain, Ohio.
e of contract, June 30, 1897.
e of approval, July 20, 1897.
e of commencement, October 18, 1897.
e of completion, not completed.

COMMERCIAL STATISTICS.

following statistics for the year 1897 relative to the commerce of the harbor t Clinton, Ohio, were compiled from information furnished by the collector of s and others:

Receipts.	Tons.	Shipments.	Tons.
	845	Fish	200
	2,202	Merchandise	400
	660	Hay	45
	1,750	Straw	26
		Grain	98
tal	5,457	Total	769

ight tonnage:

	6,226
	3,257
crease	2,969

Vessels.	Number.	Tonnage.
g	36	2,570
ng	36	2,381

gistered tonnage:

	4,951
	3,946
ncrease	1,005

ft of largest vessels using harbor, 12 feet. Largest vessels only load to 9 feet.
w vessel lines established during the year.

M M 4.

IMPROVEMENT OF SANDUSKY HARBOR, OHIO.

The harbor of Sandusky, Ohio, is in the lower part of Sandusky Bay, the water of which has depths ranging in general from 8 to 12 feet. The harbor proper is on the city front, covering a length of about 7,800 feet along and inside of a channel dredged to a depth of 17 feet. The easterly end of the dock channel is connected with the deep channel at Cedar Point by a straight dredged channel 200 feet wide and 17 feet deep and 9,500 feet long. The lighthouse on the end of the bar between the lake and the bay is 11,000 feet, by the straight channel, from the east end of city front.

The channel from the "Deep Hole" at Cedar Point to a depth of 18 feet in the lake is over 6,000 feet long, and half the distance nearest the lake is through a narrow channel of somewhat variable depth, generally exceeding 17 feet, but sometimes a little less.

Before the channels were improved by dredging and other means the depths over the bar were but 8 to 9 feet; along the city front the depth was 10 feet, and between the city and outer bar depths ranged from 9 to 12 feet through a circuitous channel.

Improvements under appropriation of June 11, 1844, were commenced in the same year by constructing a small dam or breakwater across a breach in the point which then partially separated the waters of the bay from the lake. Subsequent improvements were made in the best natural channels until 1888. From 1888 to 1894 a straight channel 200 feet wide and 17 feet deep was dredged from east end of dock channel to Cedar Point. In 1894 the other channels had filled to such extent that vessels drawing 13 feet found difficulty in reaching the wharves.

Under requirements of the river and harbor act of August 17, 1894, a survey and estimate of cost of further improvements was submitted. The project includes dredging channels inside the bay to a width of 200 feet and depth of 17 feet; over the bar 300 feet wide and 18 feet deep. It also includes a jetty 2,500 feet long from Cedar Point and a dike of equal length on the opposite side of the channel. The estimated cost was $255,000.

At the end of the last fiscal year the straight channel had been nearly all redredged to remove the fill; channel on city front had been given a depth exceeding 17 feet throughout, a width of 90 feet in west section and 110 feet in east section, and the channel over outer bar had a depth exceeding 17 feet over a minimum width of 90 feet. The jetty had been constructed from shore a distance of 800 feet.

At the beginning of the last fiscal year contracts were outstanding and incomplete for dredging and for construction of jetty from Cedar Point. In each case the work was to be carried as far as could be done with funds available for the purpose.

Dredging in channels was suspended by completion of contract July 24, 1898. The amount dredged in July was 25,133 cubic yards. The total dredged under the contract was 61,281 cubic yards from straight channel and east section of dock channel; 33,140 cubic yards from west section of dock channel, and 28,664 cubic yards from channel over outer bar. In addition to the dredging the plant was employed twelve hours and thirty-five minutes removing bowlders, most of which had been previously blasted.

Work upon the jetty from Cedar Point was suspended October 12, 1897, by completion of contract. The jetty had then been extended to a point 1,775 feet from shore at an average cost of about $13.50 per linear foot. The project contemplates a length of 2,500 feet.

jetty is a substantial construction of riprap stone placed upon
sses of brush, which project several feet beyond the foot of the
n each side. The top of the jetty, 10 feet wide, is as carefully
practicable at a grade 1 foot above mean lake level. The effect
jetty in preventing the outflowing currents from spreading to
rd is already perceptible in an increased depth of channel over
r. Soundings taken in June, 1898, disclose a channel having a
l depth of more than 18 feet throughout. It is, however, still
r, the minimum width between contours of 17 feet being 100 feet.
there is great room for improvement, the channel over the bar in
ring of 1898 was better than ever before known.

ompliance with the requirements of section 1 of the river and
r act of June 3, 1896, a complete survey was made of the bar and
els at the mouth of Sandusky Bay, and a report with estimate of
f additional improvements considered necessary to obtain a per-
nt and deep channel over the bar was submitted to the Chief of
eers under date of March 17, 1898. The report was printed with
n Document No. 362, Fifty-fifth Congress, second session, and a
s appended hereto as Appendix M M 16.

project is essentially an extension of the works included in the
t previously approved. The estimated additional cost is $240,796.
stimated cost of completing works previously undertaken is
00. Total for both, $425,796.

he belief that the completion of this additional work will result
ermanent, reliable, and deep channel of ample width over the bar,
hat it will to a large extent improve conditions in the straight
el inside the bar, the officer in charge of the improvement recom-
the adoption of the plans and the completion of the work at as
a date as may be practicable.

expenses of the survey were paid from the appropriation for the
vement. Attention is specially invited to the complete report.

following statement shows the distribution of expenses incurred
appropriation of $40,000 by act of June 3, 1896:

1896, balance unexpended of appropriation, August 17, 1894	$5,902.10
riation, June 3, 1896	40,000.00
otal	45,902.10
ng:	
ter bar, 28,664 cubic yards, at $0.14	4,012.96
aight channel and east section of dock channel, 61,281 cubic yards, t $9.75	5,974.90
st section of dock channel, 33,140 cubic yards, at $0.17	5,633.80
st section of dock channel, removing bowlders	314.83
pector of dredging and rock removal	962.50
sting rock	1,126.12
ntingencies	66.15
Total for deepening channels	18,091.26
ucting jetty:	
28.5 square yards brush mattress, at $0.29	2,560.27
562.69 tons stone, at $1.09	20,233.33
piles, at $11	121.00
perintendence	820.83
ntingencies	47.60
Total for jetty	23,783.03
s of bar and channels	1,636.78
ent toward purchase of steamer	1,500.00
and other contingent expenses	534.74
Total expenditures in two years	45,545.81

The commerce of Sandusky, while varying somewhat from year to year, as shown by the statistics received, has in general increased until its amount had grown threefold since improvements of the channels have permitted the entrance of large vessels. The harbor is especially well situated for distribution of coal from the mines in Ohio. Arrangements are now being made looking to a large increase in the freights at Sandusky Harbor. In 1897 the freights reported were less than in 1896, but the registered tonnage showed a large increase. It may be remarked that much of the coastwise freight is not reported at the local custom-house, and the returns of freights are therefore incomplete.

Sandusky Harbor is in the collection district of Sandusky, Ohio. There is a light-house on Cedar Point, with a white light of the fifth order, and a range beacon to mark the channel over outer bar. Two range lights mark the axis of straight channel, and two beacons have been completed to mark new channel over outer bar. The latter have not been lighted because the channel improvement is not sufficiently advanced.

Money statement.

July 1, 1897, balance unexpended	$29,679.45
June 30, 1898, amount expended during fiscal year	29,323.16
July 1, 1898, balance unexpended	356.29
Amount (estimated) required for completion of existing project	185,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	185,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for improving Sandusky Harbor, Ohio.

June 11, 1844	$15,000.00	August 2, 1882	$10,000.00
August 30, 1852	15,000.00	July 5, 1884	20,000.00
June 28, 1854 (allotment)	10,000.00	August 5, 1886	5,000.00
June 23, 1866	38,580.00	August 11, 1888	40,000.00
July 11, 1870	10,000.00	September 19, 1890	45,000.00
June 10, 1872	13,000.00	July 13, 1892	41,712.00
March 3, 1873	25,000.00	August 18, 1894	30,000.00
June 23, 1874	25,000.00	June 3, 1896	40,000.00
March 3, 1875	25,000.00		
August 14, 1876	25,000.00	Total	476,792.00
June 18, 1878	20,000.00	Expended to June 30, 1898	476,435.71
March 3, 1879	1,000.00		
July 14, 1880	12,500.00	Unexpended July 1, 1898	356.29
March 3, 1881	10,000.00		

NOTE.—The above is exclusive of $400 appropriated for a survey by act of May 20, 1826.

LIST OF CONTRACTS FOR IMPROVING HARBOR AT SANDUSKY, OHIO, IN FORCE DURING THE FISCAL YEAR ENDING JUNE 30, 1898.

Contract for dredging.

Name of contractor, Carkin, Stickney & Cram, Detroit, Mich.
Date of contract, August 17, 1896.
Date of approval, August 28, 1896.
Date of commencement, September 7, 1896.
Date of completion, July 24, 1897.

Contract for constructing a stone and brush jetty from Cedar Point.

Name of contractor, John Stang, Lorain, Ohio.
Date of contract, August 15, 1896.
Date of approval, August 25, 1896.
Date of commencement, September 22, 1896.
Date of completion, October 12, 1897.

COMMERCIAL STATISTICS.

statistics for the year 1897 relative to the commerce of the harbor io, were compiled from information furnished by the collector of ers:

ipts.	Tons.	Shipments.	Tons.
	91,486	Coal	367,951
les	134,455	Merchandise	25,096
	119,000	Stone	13,892
	40,000	Lime	3,290
	78,148	Cement	1,290
	46,982	Lumber	466
	17,633	Sand	1,600
	12,900	Salt	500
	9,308		
	7,920		
	4,770		
	3,464		
	4,090		
	3,500		
	2,133		
	2,100		
	577,889	Total	414,085

e:

	991,974
	1,383,455
	391,481

Vessels.	Number.	Tonnage.
	4,191	706,475
	4,176	704,736

nage:

	1,411,211
	1,046,332
	364,879

t vessels using harbor, 20 feet. Largest vessels do not load to full vessel lines established during the year.

M M 5.

IMPROVEMENT OF HURON HARBOR, OHIO.

small town about 9 miles east of Sandusky. Its harbor ied mainly by a part of the river not exceeding one-half inside the shore line, and by a large slip or dock dredged le to afford facilities for handling iron ore.

e mouth of the river was occasionally closed by a sand as in that condition in 1826, when the plan of improve- opted. The project was for parallel piers of timber crib ith stone, extending into the lake, 140 feet apart. The dredged at various times, and piers were repaired and ecessities required until 1890, when the present project of piers to a depth of 16 feet in the lake was adopted. The

estimated cost of that project, revised in 1893, was $145,000, exclusive of all expense for maintenance.

The total cost of construction and maintenance of piers and channel to June 30, 1897, was	$171,525.80
Expended during last fiscal year	736.14
Total to June 30, 1898	172,261.94

The outer end of west pier, a length of 340 feet, has been built within a few years and is in good condition, and two parts of same pier, a total of 288 linear feet, have had the superstructure rebuilt. On the east side the outer end for a length of 152 feet is nearly new, and in good condition. The remainder of the piers, a length of 892 feet on west side, and 770 feet on east side, is in very bad condition, the superstructure is in an advanced stage of decay, the cribs are worn by ice and attrition of other elements, are more or less torn apart by unequal settlement, and injured by other causes to such extent that no mere repair will suffice to put it in good condition. Aside from the bad conditions from causes above indicated, there are others which are the outgrowth of the varying conditions of navigation and commerce. In the earlier years of these improvements the draft and tonnage of vessels were small, no very great channel depths were required, and the piers therefore rested upon the bottom of the lake in depths no greater, and often less, than the depth of channel. The great development of commerce has increased the size of vessels, and the increased depths through the canals and rivers between the lakes have encouraged the construction of vessels capable of drawing 18 or even 20 feet of water. In attempting to keep pace with these depths in harbor channels the older parts of many piers have been undermined and have partially or wholly slid into the channel. These remarks apply not only to the piers at Huron, but to all other places upon Lake Erie where harbor improvements have been made by parallel piers at the mouths of rivers.

At the beginning of the fiscal year a small balance of funds remained available for the improvement. The stage of water in August was quite low and complaint was received that large steamers found difficulty in reaching the wharves. The United States dredge plant from Toledo Harbor was therefore employed to improve the channel as far as possible with available funds. From August 11 to August 25 the dredge removed 9,347 cubic yards of material from the channel in the lake outside the piers, at a cost, for operating expenses only, a little less than 8 cents per cubic yard.

While the approved project contemplates a depth of but 16 feet, there is now a good channel having a depth exceeding 17 feet at mean lake level. Owing to the location with reference to the directon of shore lines and the character of the bottom outside, the bar at Huron Harbor is less variable than at most other places on the lake, and a channel once obtained is less liable to varying depths.

The present project for improvement contemplates extending the west pier a distance of 600 feet and the east pier 568 feet. It is believed that very much better and more permanent results will be obtained if this project be modified in such manner as to make no further extensions to piers, but to construct small detached breakwaters converging toward the lake, as adopted for Conneaut and Ashtabula harbors and proposed for Lorain Harbor. The breakwaters at Huron, even if no more extensive than the additional piers included in the project, would be of much greater benefit than any mere extensions of parallel piers.

The harbor of Huron has not an extensive commerce as compared to the large shipping ports on Lake Erie. The annual average of freights for six years, from 1893 to 1897, inclusive, was 368,871 tons.

bor is in the collection district of Sandusky, Ohio. There is a fixed f the fourth order on the outer end of the west pier.

Money statement.

balance unexpended	$747.91
amount expended during fiscal year	736.14
balance unexpended	11.77
timated) required for completion of existing project	117,500.00
t can be profitably expended in fiscal year ending June 30, 1900	75,000.00

in compliance with requirements of sections 2 of river and ts of 1866 and 1867 and of sundry civil act of June 4, 1897.

and date of all appropriations for improving harbor of Huron, Ohio.

	$5,000.00	June 14, 1880	$3,000.00
	4,413.35	March 3, 1881	3,000.00
	5,935.00	August 2, 1882	2,500.00
	1,880.36	July 5, 1884	7,500.00
	3,480.00	August 5, 1886	3,000.00
	1,500.00	August 11, 1888	6,000.00
	6,700.00	September 19, 1890	16,000.00
	4,300.00	July 13, 1892	15,000.00
	2,565.00	August 18, 1894	10,000.00
	5,000.00	June 3, 1896	8,000.00
	5,000.00		
2	10,000.00	Total	172,273.71
	39,000.00	Expended to June 30, 1898	172,261.94
	1,500.00		
	1,000.00	Balance unexpended July 1, 1898	11.77
	1,000.00		

COMMERCIAL STATISTICS.

ng statistics for the year 1897 relative to the commerce of the harbor io, were compiled from information furnished by the collector of cus-rs:

Receipts.	Tons.	Shipments.	Tons.
	228,182	Coal	211,543
	5,000		
	100		
	200		
	233,482	Total	211,543

nage:

	445,025
	518,767
	73,742

Vessels.	Number.	Tonnage.
	142	134,273
	153	147,310

tonnage:

	281,583
	350,312
	68,729

rgest vessels using harbor, 20 feet. Largest vessels do not load to full ew vessel lines established during the year.

M M 6.

IMPROVEMENT OF VERMILION HARBOR, OHIO.

Vermilion Harbor is in the Vermilion River near its mouth, about 20 miles east of the entrance to Sandusky Bay, Ohio.

The improvements, commenced in 1836, consisting of parallel piers of timber crib work filled with stone, supplemented by dredging and removal of rock to a depth of 14 feet, were completed in 1879, since which time all expenditures have been for the necessary examinations of channel and for maintenance of piers.

Expended on construction and maintenance, 1836 to 1879, inclusive.....	$113,701.28
Expended for maintenance, 1880 to June 30, 1898	18,980.43
Total expenditure to June 30, 1898.....	132,681.71

It will be observed that the expenditures for maintenance have averaged about $1,000 per year, but the expenditures have fallen far short of maintaining the piers in good condition or even channel depths.

In 1879 the channel was reported as having been dredged to a depth of 14 feet, a considerable part of which was cut through a bottom of rock, which is at that place a kind of shale. There are no sand-bar formations outside the ends of piers at Vermilion, but the currents of the river are only sufficient to maintain mid-channel depths generally exceeding 11 feet, with 12 to 14 feet in places between the piers.

A part of west pier 90 feet long, removed and rebuilt in 1896, is the only part of the entire piers which is in a thoroughly good condition; 72 feet in length of west pier on the outer end, on which the light-house stands, next to the new section, can be made to last for many years with suitable repairs. The outer end of east pier, a length of 317 feet, is in fairly good condition above water, that part having been rebuilt in 1892. An additional length of 185 feet can be made to do service for a considerable time, but will need attention and repairs. The remaining parts of piers, a total of about 1,542 feet in length, are in such condition both above and below water that any attempt at repairs could not possibly produce satisfactory results.

The condition of these piers was quite fully described on page 2935, Report of Chief of Engineers for 1896, but since that date the effects of two years have been added. A section of pier on the east side, immediately inside the shore line and joining the part of 502 feet in length from outer end, has been broken entirely through, so that northeasterly storms send the seas over the beach and into the channel. But for logs and willows upon the beach the breach would be as deep as the channel itself.

A small map of Vermilion Harbor is in Report of Chief of Engineers for 1891, opposite page 2848.

No plans nor estimates for renewing or reenforcing these piers can be submitted unless required by Congress, but these statements are made in order that the conditions may be known.

The commerce of Vermilion Harbor is very small and entirely local. The total number of tons of freight reported in six years has been but 23,903, an annual average less than 4,000 tons.

The harbor is, however, considerably used by small fishing vessels which do not appear in the statistical returns. The refuge afforded to these boats gives at least some small reason for the maintenance of the piers and light-house.

An examination of the channel and piers was made in June, 1898. The expenditures of the last fiscal year have been for examinations of channel and contingent office work.

The estimate of $2,000 for completion of project is simply the unappropriated balance of an estimate of $14,000 submitted in 1882 for repairs needed at that time. The expenditure of so small a sum by itself would produce no appreciable good effects save possibly in strengthening the outer end of pier upon which the light-house stands.

Vermilion is in the collection district of Sandusky, Ohio. There is a fixed light of the fifth order on the west pier.

Money statement.

July 1, 1897, balance unexpended	$444.82
June 30, 1898, amount expended during fiscal year	425.25
July 1, 1898, balance unexpended	19.57
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	2,000.00

Amount and date of all appropriations for improving Vermilion Harbor, Ohio.

July 2, 1836	$10,000.00	August 2, 1882	$3,000.00
March 3, 1837	20,000.00	August 5, 1886	3,000.00
July 7, 1838	23,626.57	August 11, 1888	1,000.00
June 28, 1864 (allotment)	5,758.97	September 19, 1890	2,000.00
June 23, 1866	15,315.74	July 13, 1892	2,000.00
June 10, 1872	5,000.00	August 18, 1894	2,000.00
March 3, 1873	12,000.00	June 3, 1896	2,000.00
June 23, 1874	3,000.00		
March 3, 1875	10,000.00	Total	132,701.28
August 14, 1876	5,000.00	Expended to June 30, 1898	132,681.71
June 18, 1878	4,000.00		
June 14, 1880	2,000.00	Balance unexpended July 1, 1898	19.57
March 3, 1881	2,000.00		

COMMERCIAL STATISTICS.

The following statistics for the year 1897 relative to the commerce of the harbor of Vermilion, Ohio, were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Lumber	1,286	Fish	2,236
Coal	301		
Coal tar	3		
Total	1,590	Total	2,236

Total freight tonnage:	
1897	3,826
1896	3,482
Increase	344

Vessels.	Number.	Tonnage.
Entering	49	1,876
Departing	50	1,884

Total registered tonnage:	
1897	3,760
1896	4,562
Decrease	802

Greatest depth of water, about 13 feet. Largest vessels can only load to 11½ feet.
No new vessel lines established during the year.

M M 7.

IMPROVEMENT OF BLACK RIVER (LORAIN) HARBOR, OHIO.

This harbor is in the city and township of Lorain, Ohio, where the Black River empties into Lake Erie, and it would more properly be designated as the harbor of Lorain, Ohio.

The river and harbor act of May 23, 1828, made an appropriation "toward removing the sand bar at or near the mouth of Black River in the State of Ohio, by the erection of piers or other works, seven thousand five hundred dollars." A project for improving the channel by confining the current between parallel piers was therefore adopted. The piers have been extended, repaired, and parts have been rebuilt, and the channel has been dredged to keep pace as far as possible with the requirements of commerce, but no radical change in the original project has thus far been approved.

The last extension to east pier was a length of 40 feet in 1893, and to the west pier 40 feet in 1893, and 72 feet in 1895. The east pier is now approximately 1,562 feet in length, and the west pier 1,896 feet in length; there is also a pile revetment 550 feet in length inside the shore line on east side.

At the close of the last fiscal year, the work of removing and rebuilding a section of the old west pier 396 feet in length was in progress. The section of new pier was entirely completed December 24, 1897. The materials required were purchased by informal contract after procuring proposals by circular letter. The removal of old substructure and dredging to make a deeper foundation on which to rest the new work was also done by informal contract at the lowest prices which could be obtained.

The machine furnished for the dredging was of small capacity; the material to be removed for foundation contained many bowlders, and was very variable in quality. In some places the bottom was hard and in some places soft, so that the foundation obtained at a mean depth of 19.5 feet was not as uniform and level as it should have been. The alignment of the botttm of the crib was very exact; but cross walls of the crib being solid and sufficiently strong to prevent any change in cross section, the top of the crib at water level was thrown more or less out of alignment, corresponding with the varying levels in cross section of foundation, though somewhat less in amount because the width of crib at bottom is 24 feet while the height to water surface is but 19.5 feet. The varying alignment of crib was nearly corrected by gradual offsets in the timber courses of superstructure, but at considerable added expense for labor. The work involved removing about 401 feet of old pier and of filling the small space at north end and larger space at south end with temporary constructions to serve until the other parts are built. The new work is in one crib 18 feet wide, with base projecting 3 feet on each side, built according to the latest methods without dovetails. All timber ends above water, whether abutting or not, are well painted as a means of retarding decay.

The superstructure is but 4 feet above mean lake level and there are two heavy fenders of oak timber bolted longitudinally to the channel face of the pier.

The entire cost of the pier is as follows:

Purchase, hire, and repair of plant	$210.80
Mooring piles	6.00
Timber and plank, per M:	
White oak, 4,760 feet, at $20	95.20
White pine, 158,676 feet, at $19	3,014.83
Hemlock, 403,451 feet, at $11.50	4,639.69

n, per pound:	
Driftbolts, 34,797 pounds, at $0.0134	$466.28
Rods, with screws and nuts, 23,417 pounds, at $0.0139	325.50
Screw bolts, 43,570 pounds, at $0.0143	623.05
Screw bolts, 2,095 pounds, at $0.025	52.37
Spikes, 2.400 pounds, at $0.0149	35.76
Spikes, 200 pounds, at $0.0175	3.50
Washers, 3,040 pounds, at $0.0143	40.47
Washers, 1,399 pounds, at $0.0139	19.44
Washers, 368 pounds, at $0.02	7.36
ne, per cord:	
Stone, 95 cords, at $2.84	269.80
Stone, 837 cords, at $3.84	3,214.08
murrage on stone vessels	180.00
moving old pier and dredging foundations, by informal contract	3,000.00
bor and superintendence	3,112.24
Total cost of 396 linear feet of new pier	19,316.37

Items not shown in above list, but covered in the cost of labor and aterials, are the removal of 401 feet of superstructure of old work, moving, storing, and replacing 112 cords of stone from old work, and acing temporary work in 5 linear feet of pier to close intervals between w and old pier. The last pier construction by contract at Lorain arbor was in 1895.

At the prices paid under contract the 396 feet of pier at Lorain, conucted by hired labor in 1897, would have cost as follows:

60 feet white oak, at $40 per M	$190.40
,676 feet white pine, at $33 per M	5,236.31
.451 feet hemlock, at $23 per M	9,279.37
797 pounds driftbolts, at $0.03 per pound	1,043.91
417 pounds rods, at $0.03 per pound (same as driftbolts)	702.51
665 pounds screw bolts, at $0.04 per pound	1,826.60
00 pounds spikes, at $0.04 per pound	84.00
07 pounds washers, at $0.04 per pound	192.28
cords stone, at $5.75 per cord	5,349.00
moving old pier and dredging foundations by contract, assumed as same n both cases	3,000.00
lary of inspector, six months, at $125	750.00
timated cost at latest contract prices	27,654.38
Rate per linear foot, $69.83.	
tual cost by hired labor, etc	19,316.37
Difference in favor of hired labor, etc	8,338.01

Actual cost of construction per linear foot, $48.78.

The method of construction was essentially the same as that shown r timber portion of east pier at Cleveland Harbor, Ohio, shown in ates opposite page 3080, Report of Chief of Engineers, 1897. It is so shown upon plates Nos. 1, 2, and 3, accompanying this report.

After the new section of pier was in position it was found necessary o immediately remove a bank which had been thrown up or washed hrough the opening into the channel, and a dredge plant was employed for the purpose thirty-seven hours, at $9 per hour. In November, 1897, much difficulty was experienced in getting loaded vessels to and from the wharves, and a dredge was employed to deepen the channel by the removal of 4,184 cubic yards of material, at 20 cents per cubic yard.

In June, 1897, a survey was made of the channel and a width of 400 feet on each side. The result shows a good channel between piers and to deep water outside, with a minimum middle depth exceeding 18 feet.

The following estimate shows the distribution of expenses und appropriation of June 3, 1896:

On hand July 1, 1896	$30
Dredging and inspection in fall of 1896	6
Repairing east pier, 1896	
Rebuilding 396 feet west pier	19
Dredging and inspection in fall of 1897	2
Office and contingent expenses of all kinds	1
Balance on hand July 1, 1898	
Total	30

Under date of November 1, 1897, a report of a survey of the l of Black River (Lorain), Ohio, was submitted, with an estimate cost of improvement "with a view to providing better access t harbor and the safety of boats therein," as required by the riv harbor act of June 3, 1896. The report was forwarded to Congre printed in House Doc. No. 131, Fifty-fifth Congress, second sessic copy is appended hereto as Appendix M M 17.

The estimated cost of works recommended is $695,500.

The freight tonnage of Lorain Harbor is increasing rapidly, an present indications will be doubled within the next two years.

Black River (Lorain) Harbor is in the collection district of Cuyahoga There is a fixed white light of the fourth order on the outer end of west pie beacon on the inner end of west pier to form a range for entering the harbor

Money statement.

July 1, 1897, balance unexpended	$1
June 30, 1898, amount expended during fiscal year	1
July 1, 1898, balance unexpended	
July 1, 1898, outstanding liabilities	
July 1, 1898, balance available	
Amount (estimated) required for completion of existing project. Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.	3

Amount and date of all appropriations for improving Black River Harbor, (

May 23, 1828	$7,500.00	June 18, 1878	$
April 23, 1830	8,559.77	June 14, 1880	
March 2, 1831	9,275.00	March 3, 1881	
July 3, 1832	8,000.00	August 2, 1882	
March 2, 1833	2,400.00	July 5, 1884	1
June 28, 1834	5,000.00	August 5, 1886	1
March 3, 1835	4,400.00	August 11, 1888	1
July 2, 1836	6,660.00	September 19, 1890	1
March 3, 1837	6,410.00	July 13, 1892	2
July 7, 1838	5,000.00	August 18, 1894	1
August 30, 1852	5,000.00	June 3, 1896	3
June 28, 1864 (allotment)	20,000.00		
June 23, 1866	10,000.00	Total	292
June 10, 1872	20,000.00	Expended to June 30, 1898	292
March 3, 1873	20,000.00		
June 23, 1874	20,000.00	Balance unexpended July 1, 1898	
March 3, 1875	10,000.00		
August 14, 1876	6,000.00		

PLATE NO. 3.

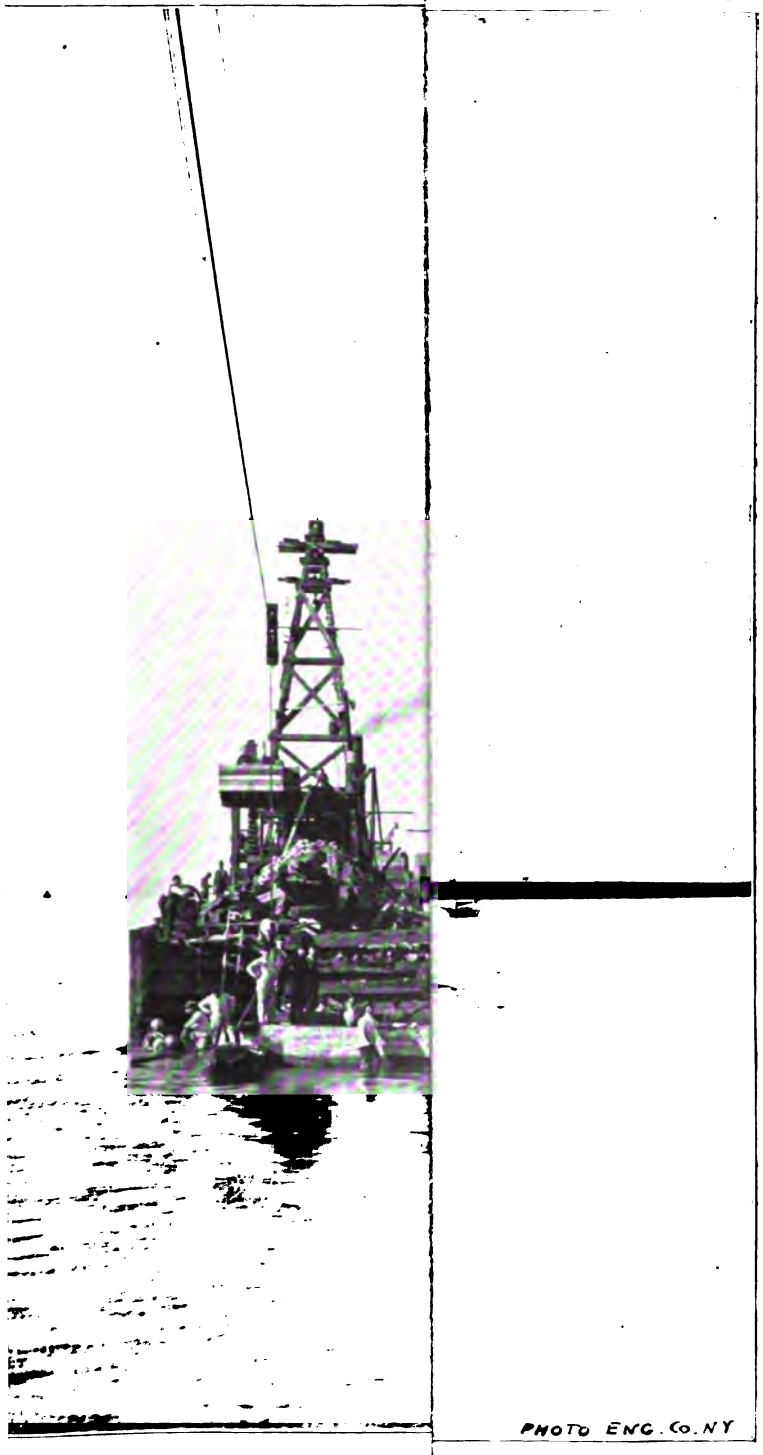


PHOTO ENG. CO. N.Y

LAYING CONCRETE B

	200		
	435,357	Total	207,224

tonnage:

	642,581
	565,219
e	77,362

Vessels.	Number.	Tonnage.
	725	480,030
	740	435,410

ed tonnage:

	915,440
	358,782
e	556,658

largest vessels using harbor, 18 feet. Largest vessels only load to 17.6
ew vessel lines established during the year.

M M 8.

IMPROVEMENT OF CLEVELAND HARBOR, OHIO.

rbor of Cleveland, Ohio, is formed mainly by the navigable
of the Cuyahoga River, including a part of the old river bed,
present channel to a point near where the river flowed into the
imes, previous to the year 1800. In the past few years a part
te front behind the east breakwater has been improved by the
ion of extensive wharves and slips, with machinery for load-
nd accommodations for freight and passenger traffic.
tire harbor accommodations at Cleveland are the direct or
esult of improvements made since 1826, when they were first

In 1895 an opening of 200 feet was made in the shore arm of west breakwater as a means of purifying the water in the anchorage basin and of forming an outlet, so that the impure water might flow along the shore without passing out at the harbor entrance and contaminating the city's water supply. See Report of Chief of Engineers, 1895 page 3103.

The anticipations have been fully justified by results. Before the opening was made the officer in charge of the improvement had, on various occasions, observed the foul and discolored water from the river passing within distinctly defined limits into the lake, and thence spreading westward around the intake crib for the city's water supply; on one occasion he observed various kinds of old refuse covering the water around the crib and connected with the river by a continuous strip of the same material. Oil refineries are situated near the river, below the head of navigation, and the refuse of petroleum, which flowed into the river and thence to the lake with the city sewage, was frequently observable, by its taste, in the city water. Since the opening in the breakwater was completed no such taste has been observed, so far as is known. It is therefore believed that the breakwater, leaving openings at both ends for currents to pass alongshore, and intervening as they do between most of the sewer outlets and the water intake crib, are not only serviceable for commercial reasons, but are now very useful allies in city sanitation. In 1896 the part of old east pier, 450 feet long, outside of harbor line, was entirely removed and a new pier 322 feet long with timber and stone substructure and masonry superstructure, was built in its place.

The river and harbor act of June 3, 1896, authorized contracts to be entered into to cover certain improvements of Cleveland Harbor at an expense not to exceed $1,354,000. The improvements include repairing west breakwater, sheathing face of east breakwater, extending east breakwater to point of completion, removing and rebuilding west pier at mouth of the river, and widening the channel.

At the close of the last fiscal year a contract had been executed for repairing west breakwater at an estimated cost of $413,843.78 upon basis of contract prices.

Work under the contract was commenced August 1, 1897, and was continued through the remainder of fiscal year except when suspended because of winter weather.

The work accomplished by the contractors to June 30, 1898, is as follows: Made 201 blocks of concrete, each containing 160 cubic feet (4 by 4 by 10 feet); 76 concrete blocks, each containing 140 cubic feet (3.5 by 4 by 10 feet), and 1 block containing 89.6 cubic feet (3.5 by 4 by 6.4 feet). Of these blocks 92 of the largest size, 44 of the next size, and the smallest block have been set in the work.

A length of 500 linear feet of the old superstructure has been removed to a mean depth of 2.5 feet below mean lake level, and has been reinforced, secured with iron rods, and otherwise prepared to receive the heavy stone blocks. Four hundred linear feet of the new concrete superstructure has been completed, and 50 feet in addition has the concrete blocks set in position. In addition to the blocks, the amount of concrete placed is 2,989.1 cubic yards. Six hundred linear feet of the lake face of the timber cribs which support the concrete have been sheathed with oak plank 4 inches thick and an average length of 13.1 feet; an additional length of 150 feet has been covered with the plank which has not been fastened with lag screws. Thirty-five thousand eight hundred and

twenty feet of old timber removed from below water has been used in reinforcing the cribs to support masonry, and 20,150.7 feet B. M. hemlock, 6,520.4 pounds lag screws, 1,013.1 pounds screw bolts, 4,320 pounds anchor bolts, 4,616.4 pounds tie-rods, and 308 pounds mooring rings have been expended in the work.

The work of repair and renewal was commenced on the north side of the opening in west breakwater and was carried northward. Accompanying this report are eight photographs to explain the condition of the old and the new work and the method of carrying on the repair.

The part now being renewed was constructed in 1879, and had therefore been standing exposed to the weather and elements for eighteen years when the repair was commenced. The wood below water was hemlock, above water it was generally of white pine except the deck joists, which were oak. The condition of the old work has been found such as to complete the assurance that the repair has not been too soon undertaken.

Much of the timber and plank had been renewed by repairs since the work was originally completed. The condition of the old timber work will be understood from the following brief description: On the harbor side the timbers of the outer wall are so badly decayed to within 1 foot above water level that it has been found impracticable to cut out cross-section samples for preservation and reference. The cross walls on the harbor side are entirely rotted off at their junction with side walls from the top downward to a plane about 3 feet above mean lake level; below that plane they are in better condition, but more or less decayed to the water level. Timbers in general are far more decayed at and near the ends and where the end of grain is exposed by gains for dovetails or other framing than at other points. The walls on lake side are less exposed to extremes of heat and vapor and they are less rotted than on the harbor side, although several courses from the top of outer wall are entirely decayed save a thin surface crust or shell. The lower half of lake face is in fair condition, except at points where cross-wall timbers are dovetailed through; at these joints the timbers are all more or less decayed.

On the lake face, from a line about 1 foot above the mean lake level to a depth of 3 feet below water, the scour of ice and other wear upon the wood has produced very noticeable effects, and these increase somewhat as the distance from shore is greater, although the part nearest the shore has been longest exposed.

At a distance of 250 to 300 feet from the starting point of work (i. e., north side of opening in shore arm), the face of the timber was worn away about one-half an inch, as shown by the projecting knots. At points near the angle on lake face the wear on the timber is such that the knots project about 1½ inches and some of the timber heads of cross walls project 2 inches. This condition has made it necessary to cut off all the knots and make the surface nearly even before putting on the sheathing of plank.

At a distance of 900 to 1,000 feet from the starting point the faces of timbers have been worn away to an irregular concave surface. On some of the timbers which were removed the top and bottom faces were 11 inches wide, and the timber midway between these faces was but 9½ inches thick. The timbers were originally 1 foot square. The maximum wear of 2½ inches was in the middle of the exposed face, and the wear along joints between timbers is but 1 inch. The maximum wear is generally along a line about 1 foot below mean surface level of the

lake. The lake has its lowest level in the winter months, so that i appears that the maximum wear upon the timbers is approximatel along the line of actual water level.

The dovetail heads of cross-wall timbers, and in places the ends o timbers halved together at the angles of cribs, are considerably wor below water level. It appears that, the "flare" of the dovetail being obliquely cut across the grain, the fiber of the wood becomes split o shredded off under the action of the sea with ice or other matter i suspension, until ultimately the dovetail no longer serves any purpos in holding the crib together, and even the shoulder on the inside i worn away.

This discussion will further explain some of the advantages which are expected from the new method of crib construction, in which there are no dovetail fastenings nor "gains" in timbers, and in which the ends of all timbers and plank above water, whether abutting o exposed, are made waterproof by a coating of tar or paint.

Plate No. 1 of photographs herewith shows a portion of the construction plant in use for removing and rebuilding superstructure. It also shows to some small degree the condition of the timber on the harbor side.

Plate No. 2 shows some of the concrete blocks, which are exceedingly hard and nearly perfect in shape. As nearly as can be determined by weighing a block accurately made to one cubic foot, the weight of the concrete is 137.5 pounds per cubic foot. The large blocks therefore weigh approximately 11 tons each. They are composed of one part Portland cement, two parts clean sand, two parts clean hard gravel, and three parts of broken stone (principally hard limestone). The inner surface of the boxes in which the blocks are made are plastered with mortar, one part cement and two of sand, to the height of each layer before it is rammed, and the outside surface is thus made smooth and even.

Plates Nos. 3, 4, and 5 show the process of laying blocks, with certain parts of the apparatus and incomplete work.

Plates Nos. 6, 7, and 8 show successive stages in the progress of the work.

Plate No. 9 (small) shows condition of timber inside of wall on harbor face.

To assist in superintending this work it has been necessary to purchase a complete outfit for a diver and to construct a platform upon boats upon which to carry the apparatus.

A good storehouse, 24 feet by 48 feet in plan and covered with corrugated iron, has been erected upon old west pier. The storehouse is so constructed that it can easily be moved to the new site when the old pier is removed.

As a part of the plant for supervision of work and making surveys in this district a small steamer has been purchased. For part payment of the purchase price an allotment of $2,500 was paid from appropriation for improving Cleveland Harbor, Ohio.

The repair of west breakwater thus far is progressing as rapidly as circumstances seem to permit.

In constructing the extension to east breakwater it has been considered desirable to have the foundation of riprap stone in place an entire year before the remainder of the structure is placed upon it. As the foundation is entirely of stone, it has been let under a separate contract. Proposals were invited by public advertisement, dated Marc

26, 1898, and were publicly opened April 29, 1898. The lowest bidder was Mr. James B. Donnelly, of Buffalo, N. Y., the price being 92 cents per ton for all the stone required, which is estimated not to exceed 100,000 tons. The amount of stone is, however, largely dependent upon the condition of the bottom, which is generally soft, and will permit the stone to sink somewhat, though the amount can not be positively determined in advance.

Work under this contract was commenced June 17, 1898, and at the end of the month the amount of stone delivered was 4,065,633 tons.

Under date of May 23, 1898, proposals were invited by public advertisement for constructing a part of west pier, removing part of old west pier, dredging, and completing east breakwater. Proposals were opened June 23, 1898. The contract has been awarded to The L. P. & J. A. Smith Co., of Cleveland, Ohio, the lowest bidder. The total estimated cost of work under this contract at the contract prices for the various items is $450,273.95, which is exceptionally low for the class of work required. It is expected that work upon the west pier will be commenced on or about August 1. The construction of east breakwater is to be commenced in the spring of 1899 upon foundation placed in 1898.

A part of the breakwater crosses the point of a shoal at and near the prolongation of Erie street, where the city for many years had its dumping ground for material dredged from the river channel. It will be necessary to dredge a cut through the point of the shoal in order to obtain a suitable base upon which to place the riprap stone for foundation. It is estimated that the amount of material to be removed will not exceed 20,000 cubic yards, measured in scows.

In the extension of breakwater eastward the cribs will in general be 216 feet long, the exact length having been determined by a convenient arrangement of the compartments, timber lengths, and grillages, and with a view to limit the size of cribs in such dimensions that each crib may be sunk in position and filled with stone in a single day. In addition to the later type of framing for the timber cribs it has been considered advisable to abandon entirely the old style of superstructure, and especially the parapet on the lake front.

The old arrangement furnished conveniences for vessels in the harbor to tie up at the breakwater, and to that extent the breakwater was a convenience and benefit. The length already available for such purposes is, however, more than 1½ miles, which is vastly more than any probable necessities will ever require unless the breakwater should in future become a wharf or quay for business purposes.

Seas from the lake striking the breakwater in an oblique direction are turned so that they "chase" along the face and are augmented by other seas as they progress. The result has been that at the harbor entrance the reflected and deflected seas and currents are added to the seas which arrive at the entrance by direct action of the winds so that the danger and difficulty of entering the harbor is greatly increased. To extend the breakwater without modification would still further increase the difficulty. The superstructure has therefore been given a slope to a line but 1 foot above mean water level, so that the seas may rise upon or entirely over the breakwater, introducing elements of friction and loss to the waves.

Incidentally the new cross section will result in a saving of expense both in construction and repair. Its benefits as a protection for the anchorage basin will be as great as if it were of the older form. Drawings are forwarded to show design of breakwater and of west pier.

Sheet No. 1 shows front and rear elevations of breakwater, section of timbers of cross walls, and a standard driftbolt, and plan of hole in which bolt is driven.

Sheet No. 2 shows plan and cross section of breakwater.

Sheet No. 3 shows elevation of an entire crib, lengths of timber, and other details.

The cribs will rest upon a riprap stone foundation, 68 feet wide on top and with natural slopes on each face. Average height of foundation, 8 feet. After the cribs have been sunk the foundation on outside of breakwater will be entirely covered with heavy riprap stone 6 feet to 8 feet deep, and on harbor side 3 feet to 4 feet deep.

Sheet No. 4 shows plan and general cross section of west pier.

Sheet No. 5 shows elevation and detail cross section of west pier and fenders.

In compliance with a requirement in the river and harbor act of June 3, 1896, a complete survey of the eastern portion of Cleveland Harbor was made, and a chart of the part surveyed was platted.

Under date of December 2, 1897, a report was forwarded to the Chief of Engineers. The report, with map, was printed in Document No. 128, Fifty-fifth Congress, second session. A copy is appended hereto as Appendix M M 18.

In the last Annual Report reference was made to the conditions upon which the project for widening the mouth of the Cuyahoga River was adopted. (Pages 3078 and 3079, Report of Chief of Engineers, 1897.)

The statements in the above report were made upon what was considered to be reliable authority. It has recently been found, however, that in so far as they relate to the action of the Pennsylvania Railway Company they were not correct, as the following statements and correspondence will show:

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, May 6, 1898.

COLONEL: Referring to previous correspondence on the subject of the land needed by the Government in connection with the widening of the Cuyahoga River, I am requested by the Assistant Secretary of War to instruct you to confer with the Pennsylvania company with a view of securing for the Government the land on the Cuyahoga River, owned by that company and desired for the aforesaid purpose. This you will do and report the result of your conference.

* * * * * * *

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Col. JARED A. SMITH,
Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, June 14, 1898.

GENERAL: In compliance with instructions in your letter dated May 6, 1898, I have conferred with officers of the Pennsylvania Railway Company and have the honor to submit the following report:

The first opportunity of consulting the general manager, who has the authority to act for the railway company in the matter of the transfer of lands required for the purpose of widening the Cuyahoga River, was on the 23d of May, when I visited the company's offices at Pittsburg, Pa., for that purpose.

After a general discussion of the whole subject I was informed that the company would consent to no other terms for the sale of the land than those offered to the city. This proposition is submitted in a letter from Mr. L. F. Loree, general manager of the company's lines west of Pittsburg, Pa. Mr. Loree's letter is inclosed herewith.

Regarding this proposition it should be remarked that it is quite possible that the number of square feet in the land required may be found, upon careful measurement, to be somewhat more than the amount indicated, in which case the aggregate sum to be paid would be correspondingly increased, as the price is based upon the rate per square foot rather than upon an aggregate sum.

It is also understood that the Pennsylvania Company has not at present an undisputed title and possession of the "Bayou property," the slip or dock having for many years been occupied and held by parties who have thus far been able to resist all proceedings to deprive them of possession.

To accompany and explain this report I forward, in a separate roll, a blue-print map* of the mouth of the Cuyahoga River upon which the lands in question claimed by the Pennsylvania Railway Company have been specially shaded with pencil.

This report has been delayed for some time for the purpose of enabling me to obtain information regarding the prices paid for land situated similarly to that now in question, as well as other points bearing more or less directly upon the acquisition of this land for the purpose of widening the river. In this I have thus far only partially succeeded, but hope to have the matter sufficiently complete to submit within a week.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers, U. S. A.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

PENNSYLVANIA LINES WEST OF PITTSBURG,
OFFICE OF THE GENERAL MANAGER,
Pittsburg, Pa., May 23, 1898.

DEAR SIR: Answering your inquiry regarding the land owned by this company and deemed to be necessary in the widening of the Cuyahoga River, I beg to advise you that on December 24 last we made the city of Cleveland the following proposition:

First. We will sell to the city our undivided one-half interest in the parcel of property on which is located the west shore arm of the Cuyahoga River swing bridge used by this company, and embracing in all 40,750 square feet, at $1 per square foot, aggregating for our interest $20,375.

Second. We will sell to the city the irregular-shaped parcel off the front of what is known as the "Bayou property," containing 22,860 square feet, at $2 per square foot, aggregating about $45,720.

Third. We secured the land in what is known as the bayou, at a cost of something over $100,000, for the express purpose of locating thereon a slip in which vessels might lie while receiving fuel coal. The business of fueling vessels using the Cleveland Harbor is a large and lucrative one and is a source of considerable profit to this company. The taking of so deep a strip off the water front of this property would make it impossible for modern boats to lie in the slip, since they would project a hundred feet into the river, and the land is by the improvement rendered valueless for the purpose for which it was secured. We have, after careful consideration, estimated our damages in this respect at $50,000, and so advised the city in the letter mentioned above.

Fourth. We should want to be held exempt from any assessments against property abutting upon the river for the improvement of the river contemplated in the taking of this land.

In this connection I beg to call attention to the fact that the land secured by the city from the Superior street viaduct to the old river bed, including a piece of property in this bayou district, from the Cleveland Terminal and Valley Railway Company cost them, on an average, over $2 per square foot, and we feel that the price we set on the land is a reasonable one.

If it is intended that the title pass directly to the United States Government, we would be willing to sell to them on the same terms.

Yours, very truly,

L. F. LOREE, *General Manager.*

Col. JARED A. SMITH,
Corps of Engineers, U. S. A.

In explanation of the letter from Mr. Loree it may be stated that the city had some time ago instituted suits against the railway company to obtain possession of certain pieces of land on the lake front which have for many years been occupied and improved by the rail-

*Omitted.

way company. When the city desired to purchase the land for wide ing the mouth of the Cuyahoga River, the officials of the railw company insisted that a settlement of the claims made by the ci should at the same time be considered, for while the officers of the co pany expressed great confidence that the city's claims could not l established, yet the pending suit served as a great embarrassment the further development of property for business purposes. An off was therefore made to the city to compromise the entire subject upc terms expressed in the following letter, a copy of which has been fu nished by the railway company:

PENNSYLVANIA LINES WEST OF PITTSBURG,
OFFICE OF THE GENERAL MANAGER,
Pittsburg, Pa., June 22, 1898.

DEAR SIR: A meeting was held at Cleveland on November 5, 1896, at which w discussed, between the Hon. Robert E. McKisson, mayor, and representatives of th company, a request made on the part of the city of Cleveland to know under wh conditions the Pennsylvania Company would vest in the city sufficient of its lan to permit of the widening they wished to make of the Cuyahoga River.

The Cleveland and Pittsburg Railroad, at the conference, expressed its willingne to forego any claim for damages on account of its bayou property and vest in th city the land wanted by the bayou and its one-half interest in the land wanted hel by the Cleveland and Pittsburg in common with the Lake Shore at the Cuyahog bridge, if the city would be willing to pay to the Cleveland and Pittsburg $25,0 in cash and relinquish all its claims to the so-called streets on Whiskey Island, i claim to the ownership of land owned by the Cleveland and Pittsburg north of Bat street, and its claim to the extension of Water and Bath streets and the land occu pied by the Cleveland and Pittsburg in the outer harbor, between the Bath stree tract and Seneca street, the Cleveland and Pittsburg further relinquishing its clai to land contemplated to be used by the city between Seneca street and Erie stree

You may say to Col. Jared A. Smith that this offer was made in good faith by thi company, and that it would still be willing to adjust the matters at issue betwee the city and itself on this basis.

Yours, truly, L. F. LOREE, *General Manager.*

Mr. W. H. SCRIVEN, *Superintendent.*

It will be observed that the railway company had in 1896 and 189 made definite offers to the city as a basis of settlement. These propc sitions are matters of record, but it is stated that the railway compan went still further, and in a personal interview intimated the willing ness of the company to withdraw its claims for the money considerati indicated in the foregoing letter if the proposition thus modified woul be accepted. To this no attention has been paid on the part of the city

In January, 1897, the matter was brought to the attention of th Chamber of Commerce of Cleveland, and a committee was appointe on the part of that body to act as an intermediary agent between th city and the railway company. It was substantially agreed by th respective parties that the railway company would submit to the com mittee the evidence by which it proposed to substantiate its claims t lands in dispute on the lake front, the city to do the same.

Three meetings were held, January 22, January 30, and February 9 at each of which the railway company was represented, and it pre sented to the committee maps and documents as agreed.

At the first of the meetings the mayor was present, but the directo of law was absent, and the mayor declined to act without the directo of law. At the second meeting the director of law was present an the mayor was absent, with a similar result. At the third meetin both the mayor and director of law were present, but "declined so t state claims and exhibit the evidences upon which the city relies t substantiate the same."

This action on the part of the mayor and director of law has indefi nitely postponed all negotiations looking to a compromise.

In the spring of 1898 the city on various occasions caused the arrest of employees of the railway company who were engaged in making improvements on the lake front, and was only barred from further acts of the same kind by a restraining order from a court of the United States.

It may be readily understood that under such circumstances the consideration demanded for the lands by the railway company, where all other points at issue are excluded, is not likely to be below the price at which such lands are in demand for business purposes. The widening of the mouth of the Cuyahoga River was recommended by the officer in charge of the improvement upon the distinct condition that the land required would be donated for the purpose. It was upon this condition that Congress authorized the improvement to be made, and the limitations of cost indicated in the act of Congress covered the estimates for distinct items of improvement in a report where the donation of land was assumed as part of the project. The improvement, if completed, will be of great benefit to the commerce of the city of Cleveland, and incidentally to the city itself.

The facts, as nearly as they can be obtained, most of them being matters of record, are here presented without comment, in order that the situation may be correctly understood.

The approved project for improving Cleveland Harbor covers only certain items of improvement which were not originally presented as a complete project nor intended for that purpose.

A large part of the outer harbor of Cleveland will ultimately require deeper water, and a very large amount of dredging is already needed. While no project nor estimate for this work can be presented, it is proper that the condition should be reported. The outer harbor has been constantly becoming more shallow since its commencement in 1876. Part of the fill is doubtless caused by drift from the lake, but the greater portion is from the city itself.

In addition to the numerous sewers and open drains which carry solid matter in suspension to the harbor, where a settling basin is formed, a vast amount of material has been dumped upon the shore and even within the limits of the harbor itself. Upon the map accompanying report of survey already mentioned, and also on map opposite page 2412, Report of Chief of Engineers, 1894, a large shoal is shown near the foot of Erie street, entirely within the harbor, which has been formed solely by dumping of material under city contracts. The dumping has been without supervision, and there is ample reason to know that much of the dumping has been still nearer the river mouth.

For several years the city has been causing material to be dumped directly into the lake on the shore. In 1897 a second bridge was built by the city across the railroad tracks, with a gradient to the shore, for the express purpose of making land by dumping into the water along the shore, in direct violation of section 6 of the river and harbor act of September 19, 1890. Under date of June 17, 1897, information was given to the United States attorney for this district, as required by section 11 of the act mentioned. No legal proceedings have been taken, but the city officials "consented" to build a fence along the shore, so that the dumping, which was continued, should not be directly into the water of the lake.

Attention is especially invited to the report of Mr. F. S. Burrowes, assistant engineer, regarding the amount of fill within the area between the harbor line and the breakwater, as completed and planned in approved project.

In the west anchorage basin the average fill over entire area in

twenty-three years is 2.81 feet, which would amount approxima 640,000 cubic yards measured in situ.

The average fill over the area immediately east of west anc basin, and extending as far as the east end of east breakwater, feet; amount in cubic yards, 488,074. From the last-mentione to east part of harbor basin, as planned, the average fill feet, and the number of cubic yards is approximately 916,593 last-mentioned area is that in which most of the material d under direction of the city authorities has been placed.

Material dumped in the east part of the harbor is, to a large drifted westward by the seas, and it is due largely to this caus the west anchorage has been so much filled.

The officer in charge of the improvements has no means of en the law save by giving information to the United States at There are, however, no means provided for obtaining the infor required in such complete detail as to secure conviction, and in t instances in which information has been presented it has been at with little or no result.

Whatever may be the reasons, the condition of shoal water sented. It may not be necessary to remove the entire amount fill, but it will surely be necessary to remove the material to a of 20 feet, which Mr. Burrowes estimates will amount to 1,500,00 yards, measured in scows. Some of the dredging is already needed, but it is understood that funds appropriated for the im ment of the harbor, as now provided by law, can not be expend dredging areas except as provided in the project for widening th

The following statement shows the distribution of expenses i

Expenses in fiscal year 1897, page 3078, Report of Chief of Engineers, 1897.	$4
Repair of west breakwater, under contract	1
Repair to east pier	
Surveys	
Allotment for purchase of steamer	
Diving apparatus	
Platform and boats for same	
Water levels	
Storehouse	
Advertising	
Office and engineering	
For fiscal years 1897 and 1898	7

The commerce of Cleveland is very large and is increasing.

Cleveland Harbor is in the collection district of Cuyahoga, Ohio. The lights to mark the entrance between breakwaters and piers, and a fog signal in rear of east end of west breakwater.

Money statement.

July 1, 1897, balance unexpended	$41
Amount appropriated by sundry civil act approved July 1, 1898	*29
	71
June 30, 1898, amount expended during fiscal year	2
July 1, 1898, balance unexpended	68
July 1, 1898, outstanding liabilities	$19,108.04
July 1, 1898, amount covered by uncompleted contracts	927,273.95
	94
Amount (estimated) required for completion of existing project	630
Amount that can be profitably expended in fiscal year ending June 30, 1900	40
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

*NOTE.—Appropriation was for $300,000, with proviso that $6,000 of the may be expended for repairs and extension of levee at Zanesville, Ohio.

Amount and date of all appropriations for improving Cleveland Harbor, Ohio.

March 3, 1825	$5,000.00	March 3, 1875	$50,000.00
March 2, 1827	10,000.00	August 14, 1876	50,000.00
March 3, 1829	12,179.00	August 14, 1876 (repair of pier)	8,000.00
April 23, 1830	1,786.56	June 18, 1878	100,000.00
March 2, 1831	3,670.00	March 3, 1879	100,000.00
July 3, 1832	6,600.00	June 14, 1880	125,000.00
June 28, 1834	13,315.00	March 3, 1881	200,000.00
July 2, 1836	15,006.59	August 2, 1882	175,000.00
March 3, 1837	10,000.00	July 3, 1884	100,000.00
July 7, 1838	51,836.00	August 5, 1886	93,750.00
June 11, 1844	25,000.00	August 11, 1888	100,000.00
August 30, 1852	30,000.00	September 19, 1890	75,000.00
March 3, 1853	145.69	July 13, 1892	100,000.00
June 23, 1864 (allotment)	20,000.00	August 18, 1894	50,000.00
June 23, 1866	59,806.00	June 3, 1896	30,000.00
July 25, 1868 (allotment)	17,000.00	June 4, 1897	350,000.00
April 10, 1869 (allotment)	13,380.00	July 1, 1898	294,000,00
July 11, 1870	20,000.00		
March 3, 1871 (allotment for repairs)	636.77	Total of appropriations	2,397,631.61
March 3, 1873	1,000.00	Expended to June 30, 1898	1,708,779.81
June 23, 1874	30,500.00		
Total previous to adoption of project for harbor of refuge	346,881.61	Unexpended July 1, 1898	688,851.80

NOTE.—Since the adoption of project for outer harbor, about $120,000 has been expended for maintenance of channel, piers, and breakwater.

Abstract of proposals for furnishing stone, in place, for foundation of extension to east breakwater, at Cleveland Harbor, Ohio, received and opened by Col. Jared A. Smith, Corps of Engineers, at Cleveland, Ohio, on Friday, April 29, 1898, at 2 o'clock p. m., standard time, in accordance with advertisement dated March 26, 1898.

[Amount available for the purpose, $100,000. Amount estimated for the purpose, $100,000.]

No. of proposal.	Name and address of bidder.	Heavy riprap stone (25,000 tons).		Filling stone (75,000 tons).		All the stone (100,000 tons).		Total of bid.
		Price bid per ton.	Total.	Price bid per ton.	Total.	Price bid per ton.	Total.	
1	James B. Donnelly, Buffalo, N.Y.	.....	.....	.....	.....	$0.92	$92,000	a$92,000
2	Alvin J. Belden and John A. Seely, Syracuse, N.Y.	$1.40	$35,000	$1.32	$99,000	1.35	135,000	135,000
3	The Kelley Island Lime and Transport Co., Cleveland, Ohio.	.....	.....	.....	.....	.975	97,500	97,500
4	Carkin, Stickney & Cram, Detroit, Mich. b	1.80	45,000	1.80	95,000	.....	.....	140,000
5	The L. P. & J. A. Smith Co., Cleveland, Ohio. b	1.50	37,500	1.16	87,000	1.20	120,000	124,500
6	Michael Rabbitt, Toledo, Ohio. b.	2.42	60,500	1.58	118,500	1.79	179,000	179,000

a Lowest bid received. b Slightly informal.

The bid of Mr. James B. Donnelly, of Buffalo, N. Y., is the lowest and is considered reasonable. I therefore recommend the acceptance of his bid.

JARED A. SMITH,
Colonel, Corps of Engineers, U. S. A.

U. S. ENGINEER OFFICE, *Cleveland, Ohio, May 2, 1898.*

Abstract of proposals for constructing a part of west pier, removing part of old west pier, dredging and completing east breakwater at Cleveland Harbor, Ohio, received and opened by Col. Jared A. Smith, Corps of Engineers, at Cleveland, Ohio, on Thursday, June 23, 1898, at 2 o'clock p. m., standard time, in accordance with advertisement dated May 23, 1898.

[Amount available for the purpose, $100,000.]

Articles.	Quantities specified.	Unit of bid.	No. 1—D. & G. Griese, Cleveland, Ohio.		No. 2—I. V. Hoag, jr., Pittsburg, Pa.		No. 3—John Gill & Sons, Cleveland, Ohio.	
			Price bid.	Amount.	Price bid.	Amount.	Price bid.	Amount.
Hemlock timber, feet B.M..	7,059,959	M feet B. M.	$19.00	$134,139.22	$23.00	$162,379.06	$17.75	$125,314.27
White pine timber ..do....	2,780,279	....do ..	29.50	82,018.23	30.00	83,408.37	31.75	88,273.86
White oak (sheathing on old work).....feet B. M..	204,462	....do ..	39.00	7,974.02	125.00	25,557.75	87.50	17,890.43
White oak (sheathing on new work)....feet B. M..	455,720	....do ..	37.00	16,861.64	100.00	45,572.00	38.00	17,317.36
White oak (other than sheathing) ..feet B. M..	111,264	....do ..	31.00	3,449.18	.50	5,563.20	35.00	3,894.24
White oak piles, linear feet.	9,720	Linear foot.	.40	3,888.00	.45	4,374.03	.45	4,374.00
Tie-rods.....pounds..	617,570	Pound .	.035	21,614.95	.03	18,527.10	.025	15,439.25
Screw bolts and washers, pounds	871,055	....do ..	.035	30,486.93	.03	26,131.65	.025	21,776.39
Lag screws.....pounds..	313,150	....do ..	.035	10,960.25	.03	9,394.50	.05	15,657.50
Drift bolts .....do....	758,366	....do ..	.03	22,750.98	.03	22,750.98	.02	15,167.32
Spikes .....do....	17,200	....do ..	.04	688.00	.03	516.00	.03	516.00
Straps.....do....	193,435	....do ..	.04	7,737.40	.07	13,540.45	.035	6,770.23
Bent plates.....do....	9,280	....do ..	.03	278.40	.07	649.60	.03	278.40
Wire nails.....do....	1,400	....do ..	.03	42.00	.03	42.00	.03	42.00
Mooring rings.....do....	180	....do ..	.08	14.40	.07	12.60	.20	36.00
Stone for filling cribs and pier foundation....tons..	131,500	Ton....	1.10	144,650.00	1.50	197,250.00	1.06	139,390.00
Stone for leveling east breakwater foundation, tons	3,500	....do ..	2.50	8,750.00	1.80	6,300.00	1.25	4,375.00
Stone for riprap protection, east breakwater...tons..	25,000	....do ..	1.75	43,750.00	2.25	56,250.00	1.06	26,500.00
Sand filling..cubic yards..	3,600	Cubic yard.	.60	2,160.00	.75	2,700.00	.50	1,800.00
Concrete or stone blocks, cubic feet.....	43,368	Cubic foot.	.23	9,974.64	.70	30,357.60	.375	16,263.00
Concrete made in place, cubic yards.....	4,565	Cubic yard.	3.65	16,662.25	8.00	36,520.00	5.25	24,422.75
Removing old west pier, linear feet	1,540	Linear foot.	16.00	24,640.00	27.00	41,580.00	5.00	7,700.00
Dredging....cubic yards..	140,000	Cubic yard.	.16	22,400.00	.21	29,400.00	.13	18,200.00
Moving storehouse	.....	.....	350.00	350.00	100.00	100.00	250.00	250.00
Total	.....	.....	.....	616,240.49	.....	818,876.86	.....	571,648.00

proposals for constructing a part of west pier, removing part of old west pier, ng and completing east breakwater at Cleveland Harbor, etc.—Continued.

[Amount available for the purpose, $100,000.]

cles.	Quantities specified.	Unit of bid.	No. 4—Michael Rabbitt, Toledo, Ohio.		No. 5—Carkin, Stickney & Cram, Detroit, Mich.		No. 6—James B. Donnelly, Buffalo, N. Y.	
			Price bid.	Amount.	Price bid.	Amount.	Price bid.	Amount.
iber, feet B.	7,059,959	M feet B. M.	$23.25	$164,144.05	$15.50	$109,429.36	$15.00	$105,899.39
imber, feet	2,780,279	....do..	33.25	92,444.28	21.50	59,776.00	24.00	66,726.70
(sheathing rk), feet B.	204,462	....do..	65.00	13,290.03	60.00	12,267.72	75.00	15,334.65
(sheathing rk), feet B.	450,720	....do..	65.00	29,621.80	60.00	27,343.20	45.00	20,507.40
(other than .feet B. M..	111,264	....do..	38.00	4,228.03	35.00	3,894.24	36.20	4,027.76
iles, linear	9,720	Linear foot.	.45	4,374.00	.26	2,527.20	.42	4,082.40
...pounds..	617,570	Pound..	.0325	20,071.03	.025	15,439.25	.02	12,351.40
and wash- ...pounds..	871,055	....do..	.035	30,486.93	.0225	19,598.74	.025	21,776.38
.....do....	313,150	....do..	.135	42,275.25	.035	10,960.25	.025	7,828.75
.....do....	758,366	....do..	.035	26,542.81	.02	15,167.32	.02	15,167.32
.....do....	17,200	....do..	.045	774.00	.035	602.00	.02	344.00
.....do....	193,435	....do..	.035	6,770.23	.02	3,868.70	.02	3,868.70
.....do....	9,280	....do..	.10	928.00	.02	185.60	.025	232.00
.....do....	1,400	....do..	.06	84.00	.04	56.00	.02	28.00
ga....do....	180	....do..	.135	24.30	.06	10.80	.10	18.00
lling cribs oundation, ...	131,500	Ton....	1.12	147,280.00	1.15	151,225.00	.81	106,515.00
veling east r founda- .....tons..	3,500	....do..	1.50	5,250.00	1.15	4,025.00	.81	2,835.00
rap protec- reakwater, ...	25,000	....do..	1.60	40,000.00	1.15	28,750.00	1.05	26,250.00
g, cubic	3,600	Cubic yard.	.67	2,412.00	.15	540.00	.70	2,520.00
tone blocks, ...	43,368	Cubic foot.	.47	20,382.96	.40	17,347.20	.26	11,275.68
de in place, s.....	4,565	Cubic yard.	7.29	33,278.85	6.40	29,216.00	5.72	26,111.80
old west linear feet..	1,540	Linear foot.	4.50	6,930.00	5.00	7,700.00	5.00	7,700.00
ubic yards..	140,000	Cubic yard.	.12	16,800.00	.12	16,800.00	.12	16,800.00
ehouse	.....	.....	150.00	150.00	500.00	500.00	150.00	150.00
.....	.....	.....	.....	708,542.55	.....	537,229.58	.....	478,350.33

Abstract of proposals for constructing a part of west pier, removing part of old wes dredging and completing east breakwater at Cleveland Harbor, etc.—Continuec

[Amount available for the purpose, $100,000.]

Articles.	Quantities specified.	Unit of bid.	No. 7—The L. P. & J. A. Smith Co., Cleveland, Ohio.		No. 8—A. F. Chapman & Co., Buffalo, N. Y.		No. 9—Jc Churchy Buffalo,	
			Price bid.	Amount.	Price bid.	Amount.	Price bid.	Am
Hemlock timber, feet B. M	7,059,959	M feet B. M.	$15.50	$109,429.36	$17.90	$126,373.26	$17.50	$123,
White pine timber, feet B. M	2,780,279	....do ..	25.00	69,506.98	27.00	75,067.53	27.50	76,
White oak (sheathing on old work) ..feet B. M..	204,462	....do ..	50.00	10,223.10	75.00	15,334.65	60.00	12,
White oak (sheathing on new work)..feet B. M..	455,720	....do ..	40.00	18,228.80	75.00	34,179.00	54.00	24,
White oak (other than sheathing)..feet B. M..	111,264	....do ..	30.00	3,337.92	34.00	3,782.98	34.50	3,
White oak piles, linear feet	9,720	Linear foot.	.25	2,430.00	.35	3,402.00	.25	2,
Tie-rods.....pounds..	617,570	Pound .	.02	12,351.40	.03	18,527.10	.03	18,
Screw bolts and washers, pounds	871,055	....do ..	.02	17,421.10	.03	26,131.65	.03	26,
Lag screws.....pounds..	313,150	....do ..	.025	7,828.75	.02875	9,003.06	.04	12,
Driftbolts.....do....	758,366	....do ..	.015	11,375.49	.0275	20,855.07	.02	15,
Spikes.....do....	17,200	....do ..	.02	344.00	.035	602.00	.03	
Straps.....do....	193,435	....do ..	.03	5,803.08	.04	7,737.40	.03	5,
Bent plates.....do....	9,280	....do ..	.03	278.40	.045	417.60	.05	
Wire nails.....do....	1,400	....do ..	.02	28.00	.03	42.00	.03	
Mooring rings.....do....	180	....do ..	.03	5.40	.06	10.80	.10	
Stone for filling cribs and pier foundation..tons..	131,500	Ton....	.80	105,200.00	1.15	151,225.00	.90	118,
Stone for leveling east breakwater foundation, tons	2,500	....do ..	.80	2,000.00	1.20	4,200.00	1.00	2,
Stone for riprap protection, east breakwater, tons	25,000	....do ..	.80	20,000.00	1.45	36,250.00	1.20	30,
Sand filling..cubic yards..	2,600	Cubic yard.	.20	720.00	.20	720.00	.40	1,
Concrete or stone blocks, cubic feet	43,368	Cubic foot.	.40	17,347.20	.42	18,214.56	.40	17,
Concrete made in place, cubic yards	4,565	Cubic yard.	5.00	22,825.00	7.00	31,955.00	5.25	23,
Removing old west pier, linear feet	1,540	Linear foot.	1.00	1,540.00	8.00	12,320.00	3.00	4,
Dredging ..cubic yards..	140,000	Cubic yard.	.08	11,200.00	.125	17,500.00	.14	19,
Moving storehouse	.....	.....	50.00	50.00	250.00	250.00	200.00	
Total	.....	.....	.....	450,273.95	.....	614,100.66	.....	541,

LIST OF CONTRACTS FOR IMPROVING HARBOR AT CLEVELAND, OHIO, IN FORC DURING THE FISCAL YEAR ENDING JUNE 30, 1898.

Contract for repair of west breakwater.

Name of contractor, Hunkin Bros., Cleveland, Ohio.
Date of contract, April 28, 1897.
Date of approval, May 19, 1897.
Date of commencement, August 3, 1897.
Date of completion, continuous contract.

Contract for furnishing stone, in place, for foundation of extension to east breakwa

Name of contractor, James B. Donnelly, Buffalo, N. Y.
Date of contract, May 12, 1898.
Date of approval, May 28, 1898.
Date of commencement, June 17, 1898.
Date of completion, November 17, 1898.

COMMERCIAL STATISTICS.

The following statistics for the year 1897 relative to the commerce of the harbor Cleveland, Ohio, were compiled from information furnished by the collector of istoms and others:

Receipts.	Tons.	Shipments.	Tons.
ron ore	2,770,265	Coal	2,028,243
Coal	6,150	Iron and steel	122,369
Lumber, lath, shingles, etc	465,115	Lumber	4,389
Grain and produce	71,858	Grain and produce	46,638
Iron and steel	31,914	Flour, meal, etc	574
Flour, meal, etc	34,831	Stone	953
Stone	213,007	Sand	1,216
Lime, cement, and plaster	20,007	Cement and plaster	681
Sugar	29,385	Miscellaneous	172,601
Sand and gravel	7,331		
Fish	1,856		
Copper	809		
Miscellaneous	88,499		
Total	3,741,067	Total	2,377,664

Total freight tonnage:	
1897	6,118,731
1896	5,522,111
Increase	596,620

Vessels.	Number.	Tonnage.
Entering	3,382	3,112,339
Departing	3,384	3,077,544
Built	8	25,503.51

Total registered tonnage (vessels entering and departing):	
1897	6,189,883
1896	5,991,656
Increase	198,227

Draft of largest vessels using harbor, 18½ feet. Largest vessels do not load to full depth.

New vessel lines established during the year were as follows: Kinsman Transit Company, Minch Transit Company, Germanic Transit Company, Hutchinson Transit Company, Lower Lake Steamship Company, Australia Transit Company, and Lumber Transportation Company.

REPORT OF MR. F. S. BURROWES, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, July 11, 1898.

COLONEL: In compliance with your instructions, I have calculated the amount of fill that has taken place in Cleveland Harbor since 1873, and the results are shown in the following table. The quantities are, of course, only roughly approximate, but are sufficiently accurate to show a marked decrease in depths throughout almost the entire harbor.

The survey of 1873 was made under the direction of Maj. F. Harwood, Corps of Engineers, U. S. A., and is the only complete record of soundings at Cleveland made near the time when the construction of the breakwater was begun, in 1876. The water level to which the soundings on the 1873 map are referred is somewhat indefinite, but as it is stated in the note that said water level is 2.5 feet below the zero of a bench mark of the city of Cleveland, and as the city base of levels is high water of 1838, it is assumed that the water level used on this map is 2.5 feet below high water of 1838. All recent soundings are referred to mean lake level, 1860 to 1875, which is 2.34 feet below high water of 1838, which would therefore make the water level used during survey of 1873 0.16 foot below that used in recent surveys. No correction was applied in the calculations for this difference in level, as it was regarded as probably less than the inaccuracy of the soundings.

Comparison has been made generally with soundings taken in 1896, except that for

the westerly half of the west basin soundings taken in 1892 were used, and between the piers and over the bar at the entrance soundings taken in 1898 were used.

The area for which the fill has been calculated is that included between the established harbor line and the breakwater, both as built and further projected. For purposes of study and comparison this area was divided into three parts in making the computations, as follows:

A. Area bounded by the established harbor line, by the shore and lake arms of the west breakwater, and by a line through the easterly end of the west breakwater, and at right angles to it. Length, 4,650 feet; width, 1,700 feet.

B. Area bounded by the established harbor line, by the line of the east breakwater as now constructed (including its extension across the entrance opening), and by lines passing through the easterly end of west breakwater and through the easterly end of east breakwater as constructed, and at right angles to it. Length, 3,000 feet; width, 1,700 feet.

C. Area bounded by the established harbor line, by the extension of the east breakwater as further projected, and by parallel lines at right angles to the main lake arm of the breakwater, and passing through the easterly end of the breakwater as constructed and through the easterly extremity of the east breakwater extension as projected. Length, about 1,850 feet; width, about 2,900 feet. The easterly limit line is nearly opposite the end of Muirson street. Included in this area is the greater part of the shoal caused by dumping material dredged from the Cuyahoga River by the city of Cleveland and others. A small part of this shoal, however, lies east of this area and is not included in the calculated amount of fill. On some parts of this shoal the fill is as much as 14 feet.

	Area.	Total fill in twenty-three years.	Average fill in twenty-three years.	Average annual fill.
	Square feet.	*Cubic yards.*	*Feet.*	*Feet.*
A (west basin)	7,905,000	824,222	2.81	0.122
B (westerly part of east basin)	5,100,000	488,074	2.58	.112
C (easterly part of east basin)	5,360,000	916,593	4.62	.201
A+B	13,005,000	1,312,296	2.72	.119
A+B+C	18,365,000	2,228,889	3.28	.143

In addition to the fill given in the above table about 300,000 cubic yards of material has been dredged from the harbor by the United States since 1873. Some dredging, probably not very considerable in amount, has also been done by the city of Cleveland and the Pennsylvania Company.

To dredge the entire harbor between the established harbor lines and the breakwater, both as built and further projected, to a depth of 20 feet at mean lake level, would require the removal of the following approximate quantities of material:

	Cubic yards.
A. Measured in place	640,000
B. Measured in place	340,000
C. Measured in place	300,000
Total	1,280,000

This would probably amount to 1,500,000 cubic yards, measured in scows.

Very respectfully, your obedient servant,

F. S. BURROWES,
United States Assistant Engineer.

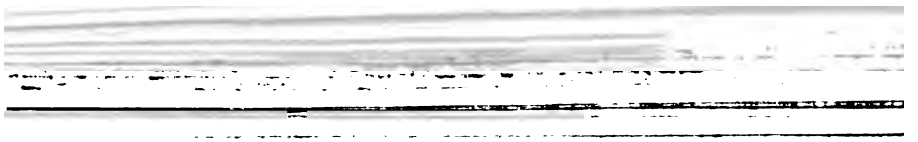
Col. JARED A. SMITH,
Corps of Engineers, U. S. A.

M M 9.

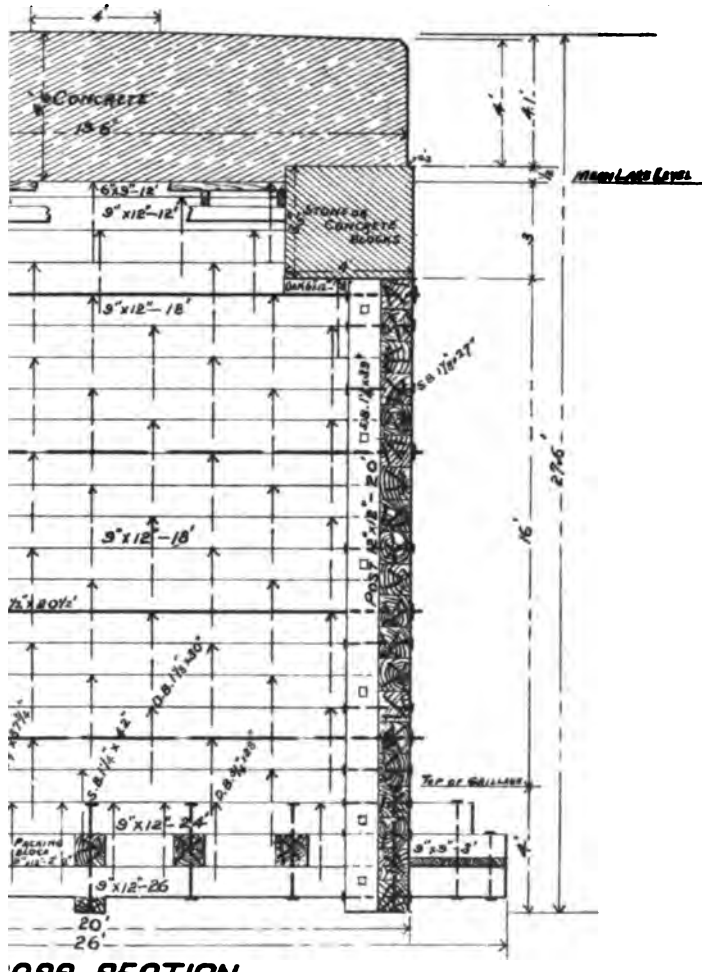
IMPROVEMENT OF FAIRPORT HARBOR, OHIO.

The harbor of Fairport, Ohio, is near the mouth of the Grand River and covers a distance of nearly 7,500 feet, measured from the outer end of the piers.

The first improvement made at the mouth of the Grand River in 1825, when the sand bar extended entirely across the mouth, consisted of piers of timber crib work filled with stone. They were built about 200 feet apart and, starting from a point inside near the shore line,



SHEET No. 5



CROSS SECTION

U.S. Engineer Office
Cleveland, Ohio.
To accompany annual report for
fiscal year ending June 30, 1898.

Jared C. Smith

Colonel, Corps of Engineers, U.S. Army.

Eng 55 3

extended across the bar to the lake. The piers have since been modified, renewed, repaired, and extended, as the necessity has arisen, and the depths have been maintained by dredging in the channel and across the bars. At times two bars have formed outside of the piers with an interval of deep water between. In two years preceding June 30, 1897, the cost of dredging alone was nearly $11,000.

The total expended upon the improvement from 1825 to June 30, 1898, for construction and maintenance has been $377,384.36.

Outstanding liabilities to the amount of $769.92 are for dredging in June, 1898.

The latest extensions to the piers were made in 1893.

The inner ends of the original piers are not now definitely located, because they have not been maintained by the United States. The parts now definitely remaining are a length of 2,370 feet on west side and of 1,765 feet on east side. A length of about 650 feet of the pier on east side has been occupied, used, and partly rebuilt in the style of a wharf front. For remarks upon this subject attention is invited to page 3111, Report of Chief of Engineers, 1895.

In compliance with requirements of public resolution approved March 24, 1896, a report of a survey and an estimate of cost amounting to $510,000 for the improvements recommended was submitted to Congress April 3, 1896. The river and harbor act of June 3, 1896, appropriated $30,000 for continuing the improvement of the harbor, and provided that "not less than $20,000 shall be applied toward the construction of a breakwater according to the project submitted April 3, 1896."

In the Annual Report of Chief of Engineers, 1896, page 2925, it was estimated that the balance of appropriation of August 17, 1894 ($10,643.18), available July 1, 1896, would be sufficient for purposes of maintenance until further appropriations would be made available. The entire amount of $30,000 appropriated was therefore deducted from the estimated cost of $510,000, to arrive at the estimated amount still required for completing the project. In one year from that time, however, the expenses of dredging alone had exceeded $10,000, and it had become necessary to reserve for maintenance of channel and piers $10,000 of the appropriation of $30,000, leaving only $20,000 to be expended upon the breakwater, that being the minimum amount required for that purpose by the act of Congress. (See Report of Chief of Engineers, 1897, p. 3084.) The amount to be applied upon the project for breakwater, etc., is therefore but $20,000, and only that amount should be deducted from the estimated cost to obtain estimated amount required for completion. That estimate, as given in Annual Report for 1897, is therefore corrected. (See project in letter on page 3084, Report of Chief of Engineers, 1897.)

In the last fiscal year the expenditures for maintenance of channels at Fairport have been unusually small. Complaints were made of bars and very shallow water early in April, 1898, and a survey and map of the channel and bar were therefore made. The map showed that the sand bar extended around the end of west pier and had also formed slightly from the eastward, but left a channel with a depth exceeding 13 feet over a width of more than 100 feet across the bar directly on the range of east pier and beacons, with sufficient room to turn vessels to and from the channel between piers where the depth exceeds 20 feet throughout.

Dredging in the early spring is exceedingly expensive because of the almost constantly prevailing winds and seas, which make it impossible to work, except at rare intervals with the type of dipper dredges in use on Lake Erie. If done by contract, such small amounts of dredging as

early as April must necessarily involve the extra risk, expense, l
lost time of getting a dredge plant to and from the locality, an
price to cover full time of plant and crews when but little can
accomplished.

The channel through the bar was therefore carefully buoyed, a
blue-print maps of the channel were sent to shippers' agent at Fa
port. As soon as it was considered reasonable on business princip
to commence the dredging, the United States dredge plant from Tol
was taken to Fairport. Dredging was commenced May 19, and c
tinued until May 28, when the greatest part of the bar had b
removed and work was suspended in order that the dredge mi
attend to similar work at Ashtabula and Conneaut. The work
Fairport was resumed June 24 and continued to June 30, when it w
completed.

A map made from a survey of the channel, June 9 and 10, 18
shows a central depth exceeding 20 feet over the first bar near the e
of piers, and exceeding 19 feet over the second bar, the top of whic
about 800 feet farther into the lake. The indications are that a la
amount of dredging will be required before the end of the present fis
year, because the bars are very near the channel on the west side, a
the depth of water over them is 3 to 4 feet less than is required
loaded vessels.

It is confidently believed that the construction of the breakwat
will entirely prevent the formation of bars by the action of winds a
waves, though it will of course not effect any reduction of mater
which may be brought down the river. The breakwaters will a
greatly facilitate the entrance of vessels because of greater width a
depth. It is very desirable that the breakwaters should be push
forward as rapidly as possible.

Fairport Harbor is in the collection district of Cuyahoga, Ohio. There is a fi
white light of the fourth order on the bluff, and a range of two beacons on the e
pier.

Money statement.

July 1, 1897, balance unexpended	$30,270
June 30, 1898, amount expended during fiscal year	1,781
July 1, 1898, balance unexpended	28,489
July 1, 1898, outstanding liabilities	769
July 1, 1898, balance available	27,719
Amount (estimated) required for completion of existing project	490,000
Amount that can be profitably expended in fiscal year ending June 30, 1900	300,000
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for improving Fairport Harbor, Ohio.

March 3, 1825	$1,000.00	June 18, 1878	$5,000
May 20, 1826	5,620.00	June 14, 1880	3,000
May 19, 1828	9,135.11	March 3, 1881	10,000
April, 23, 1830	5,563.18	August 2, 1882	10,000
March 2, 1831	5,680.00	July 5, 1884	10,000
July 3, 1832	2,600.00	August 5, 1886	18,750
June 28, 1834	10,000.00	August 11, 1888	10,000
July 2, 1836	6,000.00	September 19, 1890	20,000
July 7, 1838	10,000.00	July 13, 1892	35,000
June 11, 1844	10,000.00	August 18, 1894	20,000
August 13, 1852	10,000.00	June 3, 1896	30,000
June 28, 1864	24,453.24		
June 23, 1866	24,072.00	Total	405,873
March 2, 1867	60,000.00	Expended to June 30, 1898	377,384
June 23, 1874	20,000.00		
March 3, 1875	15,000.00	Unexpended July 1, 1898	28,489
August 14, 1876	5,000.00		

COMMERCIAL STATISTICS.

The following statistics, for the year 1897, relative to the commerce of the harbor of Fairport, Ohio, were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Iron ore	1,128,198	Coal	185,318
Grain	268,098		
Merchandise	169,610		
Total	1,565,906	Total	185,318

Total freight tonnage:	
1897	1,751,224
1896	1,897,070
Decrease	145,846

Vessels.	Number.	Tonnage.
Entering	518	882,905
Departing	488	788,076

Total registered tonnage:	
1897	1,670,981
1896	1,698,809
Decrease	27,828

Draft of largest vessels using harbor, 20 feet. Largest vessels only load to 18 feet. No new vessel lines established during the year.

M M 10.

IMPROVEMENT OF ASHTABULA HARBOR, OHIO.

Ashtabula Harbor is in and adjacent to the Ashtabula River, near its mouth. The room and facilities afforded by the river have been much increased by docks and wharves constructed by the Pennsylvania and the Lake Shore and Michigan Southern Railway companies.

The first improvements were made under an appropriation of $12,000 by act of May 20, 1826, "to remove obstructions at the mouth of Ashtabula Creek." Water was but 2 feet deep over the bar and solid rock was at a depth of 9 feet near the shore line.

The plan of improvement was the same as for other similar places—parallel piers of timber cribs filled with stone to confine and protect the channel. The piers were at first placed upon the natural bottom on each side of the channel and 168 feet apart. They were subsequently repaired, extended, and renewed, and the channel was made deeper and wider as the requirements of navigation increased, until the end of the last fiscal year. The width between piers at outer end was then 213 feet and the depth in channel was 20 feet throughout from the lake to the county bridge, which is about 2,000 feet from outer end of west pier. The piers have been extended as far as is now considered necessary.

At the end of the last fiscal year work was in progress constructing a section of west breakwater, shore end, 432 feet long and 30 feet wide, with grillage timbers projecting in such manner as to make the base 34 feet wide.

The part below mean water level was constructed in two cribs of 216 feet length each. The first crib was sunk in position August 9, and the second crib was sunk August 27 on the shore end of the first. The outer crib of the two was placed in position first because it would afford some protection in sinking the second crib, and would to some extent check the movement of sand into the trench which had been excavated to rock as a site for the cribs. Work under the contract was completed September 28.

To prepare the foundation for the breakwater, it became necessary to scrape from the rock surface the overlying very fine muddy sand, which had a depth ranging from 1 foot to 2 feet. The removal of this material was very difficult, and was made more so by persistent and strong winds which prevailed at the time. The U. S. dredge *Maumee*, tug, and scows pertaining to Toledo Harbor improvement were employed for the purpose.

In sinking the first crib some difficulty was experienced by the contractor, who did not have enough stone in sight to completely fill the compartments. In a somewhat heavy sea which followed the sinking of crib the jarring and lifting caused by waves raised the crib a few inches, so that some of the filling stone near the middle passed through the grillage and fell under the walls. When the crib was finally filled the uneven base thus produced caused it to be bent or "hogged" slightly upward in the middle and the top was thrown slightly out of alignment. The work was, however, completed in good shape, and in strength and appearance it is vastly superior to any of the timber-crib and stone piers or breakwaters built by the former methods of dovetail framing and open interior walls.

The outer face of the breakwater has a sheathing of white-oak plank extending from 2 feet above to 4 feet below mean water level. The plank is fastened with lag screws. The inner face of breakwater has two horizontal fenders of 6-inch by 12-inch white oak, the upper fender being near the top and the lower near the water level.

The harbor side of breakwater is raised 5 feet above mean lake level over a width of 15.5 feet, and the lake side is raised to form a parapet 14 feet 6 inches wide, with the top 10 feet above mean water level. To reduce the liability of injury to the fenders on harbor face, after contract work was completed, pieces of 12-inch by 6-inch oak were halved together in the shape of a cross, having the vertical piece as long as the space between fenders and the horizontal piece about 2 feet longer and wedge shaped at the ends. These pieces were bolted to the crib, between upper and lower fenders, at intervals of 18 feet.

The section of breakwater at Ashtabula presents several new features in this class of work, and drawings in two sheets showing the design are therefore forwarded to accompany this report. Sheet No. 1 shows the elevations and cross section. Sheet No. 2 shows the plan and end elevation. The drawings will sufficiently explain the design, but it may be mentioned that every fourth compartment in the cribs was planked over at the bottom in order that they might be sunk without the danger of getting stone under the walls. The difficulty experienced was because the contractor did not make sufficient use of the means thus provided.

The wide sand beach on west side of harbor entrance has been a source of great injury to the channel and of considerable expense in dredging. The sand of the beach is blown along by the prevailing westerly winds and falls over the pier into the channel, where part of it remains until removed by dredging and part is pushed along to the

end of piers, when river currents are sufficiently rapid, and thus helps to form the bar.

To check as far as possible this source of injury and expense, a strong board fence 650 feet long and 6 feet high was constructed across the beach a short distance west of west pier.

For the same purpose two strips were planted with small willow slips and roots. The first strip was 170 feet long and 25 feet wide and the second 280 feet long and 50 feet wide, with willows planted at intervals of 5 feet over both strips.

In the spring of 1898 a shoal had formed a short distance outside the ends of piers upon which the depth of water was but 16 feet in mid-channel. There was, however, a depth of nearly 19 feet in an oblique channel on west side of shoal and nearly 18 feet deep on east side. The shoal and channel were therefore marked by buoys until the obstruction was removed by dredging, from May 31 to June 10, inclusive. The United States dredge plant was employed for the purpose as a matter of economy. The amount of material, all fine sand, removed was 4,860 cubic yards, at a cost of $407.50 for the pay roll of employees and running expenses of plant.

Two examinations and maps of the channel were made in 1898, one before and one after dredging. The channel is now free from obstructions and has a minimum central depth of 20 feet.

A record of water gauge has been kept throughout the year. A small storehouse has been repaired and public property has been stored.

The total cost of 432 feet of breakwater may be given as follows:

Dredging sand from site	$975.47
Paid contractor	45,188.21
Reenforcing fenders	220.23
Purchase and hire of plant	10.71
Supervision of contract	859.42
Contingencies, office, engineering, surveys, etc. (approximate)	2,745.96
Total	50,000.00

The other expenditures of the year have been as follows:

Outstanding liabilities of previous year	$187.82
Protecting beach with fence and willows	408.84
Purchase and repair of plant	34.57
Allotment for purchase of steamer	1,250.00
Surveys, office and other contingencies	591.19
Total	2,472.42
Balance unexpended July 1, 1898	1,254.06

Of the unexpended balance the amount of $480.11 is an outstanding liability for dredging in June, 1898.

The effect of the small section of breakwater, both upon the bar and upon the seas in westerly winds, is already apparent and beneficial, although it was hardly anticipated that so small an amount by itself would produce any appreciable effects.

The freight tonnage of Ashtabula Harbor is very large, exceeding 4,000,000 tons in 1897. The protection and facilities to be afforded by the breakwaters are much needed.

Ashtabula Harbor is in the collection district of Cuyahoga, Ohio. There is a fixed white light of the fifth order varied by flashes and a fog signal operated by steam upon the west pier; also, a beacon near the shore, to form a range with the other light for vessels approaching the harbor.

Money statement.

July 1, 1897, balance unexpended	$53,726.48
June 30, 1898, amount expended during fiscal year	52,473.42
July 1, 1898, balance unexpended	1,253.06
July 1, 1898, outstanding liabilities	480.11
July 1, 1898, balance available	772.95
Amount (estimated) required for completion of existing project	480,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	480,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

LIST OF CONTRACTS FOR IMPROVING HARBOR AT ASHTABULA, OHIO, IN FORCE DURING THE FISCAL YEAR ENDING JUNE 30, 1898.

Contract for constructing part of west breakwater.

Name of contractor, The L. P. & J. A. Smith Co., Cleveland, Ohio.
Date of contract, March 26, 1897.
Date of approval, April 22, 1897.
Date of commencement, May 5, 1897.
Date of completion, September 30, 1897.

Amount and date of all appropriations for improving Ashtabula Harbor, Ohio.

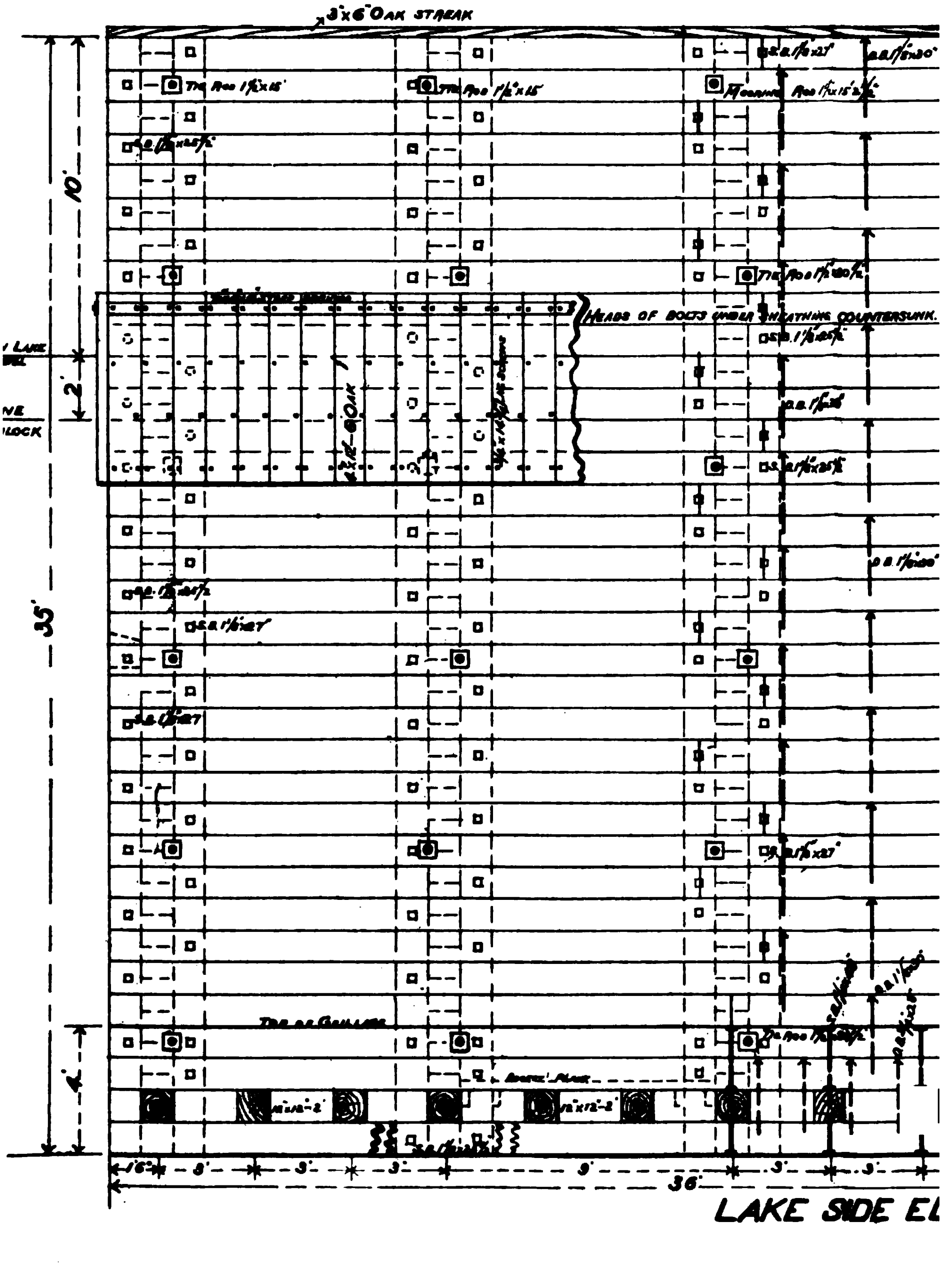
May 20, 1826	$12,000.00	August 14, 1876	$5,000.00
May 19, 1828	2,403.50	June 18, 1878	12,000.00
March 3, 1829	6,940.25	March 3, 1879	9,000.00
March 2, 1831	7,015.00	June 14, 1880	20,000.00
July 3, 1832	3,800.00	March 3, 1881	20,000.00
March 2, 1833	3,400.00	August 2, 1882	20,000.00
June 28, 1834	5,000.00	July 5, 1884	22,500.00
March 3, 1835	7,591.00	August 5, 1886	30,000.00
March 3, 1837	8,000.00	August 11, 1888	25,000.00
July 7, 1838	8,000.00	September 19, 1890	40,000.00
June 11, 1844	5,000.00	July 13, 1892	70,000.00
August 30, 1852	10,000.00	August 18, 1894	75,000.00
March 3, 1853	42.60	June 3, 1896	50,000.00
June 23, 1866	24,708.82	Total	662,401.21
March 2, 1867	54,000.00	Expended to June 30, 1898	661,147.15
March 3, 1871	15,000.00	Balance unexpended July 1, 1898	1,254.06
June 10, 1872	15,000.00		
March 3, 1873	16,000.00		
June 23, 1874	35,000.00		
March 3, 1875	25,000.00		

COMMERCIAL STATISTICS.

The following statistics for the year 1897 relative to the commerce of the harbor of Ashtabula, Ohio, were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Iron ore	3,365,699	Coal	926,904
Stone	6,582	Lumber	2,160
Lumber	5,516	Merchandise	6,500
Railroad ties	2,240		
Fish	1,070		
Total	3,381,107	Total	935,564

ASHTABULA HARBOR, OHIO.



LAKE SIDE EL

largest vessels using harbor, 20 feet. Largest vessels do not load to full

sel lines established were: The Western Transit Company, and the Fishing Company.

M M 11.

IMPROVEMENT OF CONNEAUT HARBOR, OHIO.

ıut Harbor is at and near the mouth of Conneaut Creek, Ohio, rtheastern part of the State. The first improvement was made ovisions of an act of Congress approved March 2, 1829. It . of parallel piers of timber and stone 115 feet apart extended e bar into the lake.

een appropriations were made and expended for construction ntenance of the piers, until 1880, the total amount being 39.

ısiness of the port not being sufficient to justify further main- no further appropriations were made until 1892, when new ial conditions had arisen. The old piers on the east side were ruins in the nature of obstructions to be removed, and prac- ıe same on west side, save that a part about 500 feet long g outward from the shore could be utilized by repairing and ; it a few years, so that the new constructions could be first ere most needed. In 1893 the channel was entirely insufficient ;ation by anything larger than fishing boats; the least depths bar were but 3 feet, although the depth had been 8 feet and ;s 11 feet while the piers were in good condition.

the acts of July 13, 1892, and February 24, 1893, a project was to construct parallel piers 200 feet apart extending to a depth t in the lake.

ıpliance with a joint resolution of Congress approved March a plan and estimate were submitted for the construction of erging breakwaters, to afford a depth of 25.5 feet in an entrance wide, to complete a part of the piers previously planned, and a depth of 20 feet or more in the protected area. The report,

twenty-fourth, eighteen hundred and ninety-six." The estimated cost of the project, including the work done under two previous appropriations, was $610,000.

The expenditures to June 30, 1898, have been:

From 1829 to 1880	$112,629.39
From 1892 to 1897	81,515.62
In last fiscal year	37,497.99
Total	231,643.00

At the beginning of the fiscal year work was in progress constructing a length of 282 feet of west breakwater in two cribs of 144 feet and 138 feet length, respectively.

The first crib, 144 feet long, was sunk in position July 31, and the second, of 138 feet length, was sunk and filled with stone August 23. The superstructure, 282 feet long, was completed November 30, and the riprap protection was completed in December.

The rock overlying a part of the channel between piers dips so abruptly to the northward and eastward, as to lead to the conclusion that it would not again be reached within the limits of depth proposed for the breakwater foundation. The breakwater was, therefore, provided with an extended base, having a width of 36 feet, while the general width for that inner section was to be but 24 feet. It was also arranged to protect the sand bottom of the lake along both outer and inner faces of breakwater with mattresses of brush covered with heavy stone.

Shortly before dredging the foundation it was discovered that the underlying rock at that place would be found at approximately the grade on which it was proposed to place the bottom of the cribs, viz: A depth of 23.5 feet below mean lake level. The presence of the underlying rock made the dredging of foundation very difficult. A dredge, employed under informal contract to remove the sand in such manner as to make an even and level surface, had its machinery broken after a short time. To prevent delay in sinking the crib, the United States dredge plant was taken from Ashtabula to complete the foundation for first crib.

The two cribs rest upon the rock, which is somewhat irregular upon its surface, the mean depth being 23.5 feet. The weight of stone is sufficient to make the bottom of timber work conform to some extent to the rock surface, so that the top alignment shows corresponding, though smaller, variations. A sheathing of white oak, 4 inches thick and 6 feet long, secured by lag screws, is placed upon the lake face and south end of the breakwater. It covers the face from a line 2 feet above to 4 feet below mean lake level.

For strength and class of workmanship the section of breakwater has no superior in construction of timber crib work and stone previously built upon the lakes.

The entire cost of the section of breakwater was as follows:

Dredging foundation	$997.40
Timber and plank, per M:	
White pine, 201,276 feet B. M., at $19.40	3,904.75
White oak, 22,436 feet B. M., at $19	426.27
Hemlock, 455,675 feet B. M., at $10.98	5,003.32
Iron and steel, per pound:	
Screw bolts and washers, 52,141 pounds, at $0.0134	698.69
Drift bolts, 50,284 pounds, at $0.0129	648.66
Lag screws, 4,437 pounds, at $0.0134	59.45
Rods, with screws and nuts, 31,048 pounds, at $0.0134	416.04
Spike, 4,200 pounds, at $0.0149	62.58

Iron and steel, per pound—Continued.	
Ladders, 198 pounds, at $0.0159	$3.15
Drift bolts, 435 pounds, at $0.025	10.88
Screw bolts and washers, 642 pounds, at $0.021	13.47
Stone, per ton:	
Stone for filling cribs, 6,916.52 tons, at $1.18	8,161.49
Riprap stone (on cars), 1,107 tons, at $0.95	1,052.35
Demurrage on stone vessels	450.00
Purchase and repair of plant	236.23
Labor and superintendence	6,989.08
Total	29,133.81

Cost per linear foot, about $103.31.

The contract price for stone delivered at Conneaut was greater than at Ashtabula. With the exception of the single item of stone, which was procured by contract, the materials and labor on the breakwater at Conneaut cost about $300 less than the same materials would cost at the contract prices for the section of breakwater 432 feet long at Ashtabula Harbor.

In August, 1897, a small amount of dredging was done to remove obstructions and deepen the channel over the bar. In October the stage of water in the lake was nearly 1 foot below mean level, and very great complaint was made of the difficulty in getting vessels to and from the wharves. An informal contract was therefore made for dredging, and 9,406 cubic yards of material were removed, at a cost of 20 cents per yard, besides engineering and inspection. The channel was dredged to a depth of 20 feet at mean lake level. An examination of the channel made June 7, 1898, showed a less depth of water than before the dredging in the fall of 1897. Such a result was fairly anticipated, for the officer in charge of the work believed that the dredging would "not result in any permanent benefit," and that a little care not to overload the "vessels at this season of the year, when the lake surface is below mean level and is varied by winds, would cost the shippers less than it will cost the United States to attempt to secure the depths they desire, regardless of the general condition of the improvement at the place where that depth is wanted." The number of vessels which entered and cleared after the dredging was commenced was very few, and of these the only detentions were the barge *Tyrone* in charge of a tug, which remained aground about one hour October 27, because the tug did not keep in the channel, and barge No. 31 and steamer *Fairbairn* which touched and were detained about ten minutes November 4, with lake surface 1.1 feet below mean level. The subject has been here mentioned because it explains the expenditure of a small part of the appropriation and illustrates the greater readiness of shippers to make importunate and unreasonable demands for full channel depths late in the season when the lake is usually at a low stage, rather than to lose a small part of the profit by loading vessels to suit the conditions.

In June, 1898, the United States dredge plant was taken to Conneaut, and the channel was deepened to 20 feet by the removal of 6,370 cubic yards of material from the bar at a cost, including towing expenses to and from Ashtabula, a little less than 10 cents per cubic yard. The depths thus obtained will remain until obliterated by the autumn storms.

In October and November, 1897, very heavy northeast storms caused seas to break entirely over the beach on the east side of east pier and revetment and into a small bayou. It became necessary to immediately protect the sheet piling and close the break in the beach to prevent injury to the channel and revetment. A quantity of brush, which had

been cut for mattresses to protect sand foundation of breakwater, was placed in and across the opening and loaded with 922 tons of heavy riprap stone. The same storms made a very bad break in channel side of old west pier near the rear beacon of range, endangering the safety of the beacon itself. The break was repaired by placing in it 451 tons of heavy riprap stone.

The beach on east side has been entirely restored. The west pier is as strong as before the injuries, and the channel over a width of 100 feet has a depth exceeding 20 feet at mean lake level. The outer end of west pier was repaired and strengthened in the fall of 1897.

The appropriation of June 3, 1896, had been expended, as follows:

On hand July 1, 1896	$40,180.92
Materials and services, construction of 282 feet west breakwater, shore end	29,133.81
Repairs to east pier and revetment	765.18
Stone and labor, repairing break in beach, 922 tons, at $1.15 per ton	1,060.30
Repair to outer end, west pier	129.41
Repair to break in old west pier, 451 tons riprap, at $1.15	518.65
Dredging bar and channel	3,889.00
Allotment for purchase of steamer *Visitor*	1,250.00
Purchase and repair of plant for work on piers	25.94
Office and other contingent expenses	2,457.23
Balance unexpended July 1, 1898	951.40
Total	40,180.92

It will be observed that a little less than $31,000 of the amount expended, including contingent expenses, has been applied to construction under the project, and the balance, a little more than $9,000, has been applied to repairs and other expenses of maintenance. In the last Annual Report it was anticipated that but $5,000 of the appropriation would be applied to maintenance, and the estimated amount for completion of project was upon that basis. The amount estimated for completion of project is therefore amended so that the amount deducted from original estimate of $610,000 includes only the sums which have been or are to be applied upon the project.

Of the amount unexpended, the amount of $634.65 is due for services, etc., dredging channel in June, 1898, and $75 is due for services.

The freight tonnage of Conneaut Harbor has increased from 1,265.6 tons late in the fall of 1892, to 589,368 tons in the year 1897, the average annual increase has therefore exceeded 100,000 tons.

Conneaut Harbor is 13 miles east of Ashtabula Harbor and is near the boundary between Ohio and Pennsylvania. It is in the collection district of Cuyahoga, Ohio. There are two fixed white lights of the sixth order upon the west pier at the mouth of the river, forming a range for vessels approaching to enter the harbor.

Money statement.

July 1, 1897, balance unexpended	$38,484.38
June 30, 1898, amount expended during fiscal year	37,497.99
July 1, 1898, balance unexpended	986.39
July 1, 1898, outstanding liabilities	709.65
July 1, 1898, balance available	276.74
Amount (estimated) required for completion of existing project	499,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	300,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for improving Conneaut Harbor, Ohio.

March 2, 1829	$7,500.00	March 3, 1873	$400.00
April 23, 1830	6,135.65	June 23, 1874	1,500.00
March 2, 1831	6,370.00	March 3, 1875	1,000.00
July 3, 1832	7,800.00	June 14, 1880	6,000.00
July 2, 1836	2,500.00	July 13, 1892	40,000.00
March 3, 1837	5,000.00	August 18, 1894	40,000.00
July 7, 1838	8,000.00	June 3, 1896	40,000.00
June 11, 1844	5,000.00	Total	232,629.39
August 30, 1852	10,000.00	Expended to June 30, 1898	231,643.00
June 23, 1866	20,513.74	Unexpended July 1, 1898	986.39
March 2, 1867	10,000.00		
April 10, 1869 (allotment)	8,910.00		
July 11, 1870	6,000.00		

COMMERCIAL STATISTICS.

The following statistics for the year 1897 relative to the commerce of the harbor of Conneaut, Ohio, were compiled from information furnished by the collector of customs and others:

Receipts.	Tons.	Shipments.	Tons.
Iron ore	551,417	Coal	29,170
Lumber	1,151	Merchandise	530
Stone	7,540		
Merchandise	90		
Total	560,198	Total	29,700

Total freight tonnage:

1897	589,368
1896	443,031
Increase	146,337

Vessels.	Number.	Tonnage.
Entering	443	643,143
Departing	440	641,520

Total registered tonnage:

1897	1,284,663
1896	1,519,173
Decrease	234,510

Draft of largest vessels using harbor, 20 feet. Largest vessels do not load to full depth. No new vessel lines established during the year.

M M 12.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Arrangements have been completed for the removal of the wreck of a dredge in the channel about 750 feet outside the piers at Monroe Harbor, Michigan, under provisions of section 4 of the river and harbor act approved June 14, 1880.

The following correspondence is given in explanation of the conditions which have made this action necessary:

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, June 1, 1898.

GENERAL: Under date of August 21, 1897, proposals for dredging a channel at Monroe Harbor, Michigan, were invited by circular letter, the proposals to be opened ten days later. The entire amount available being but $4,250 the specifications covered only such points as would enable the bidder to understand the kind of work to be done by the cubic yard without definite specifications regarding plant to be employed.

Among several bids received the lowest was that of M. J. Griffen, of Detroit, Mich., at 11¼ cents per cubic yard, and the proposal was therefore accepted.

Dredging was commenced September 10, 1897, but with a plant so poor that little progress was made. On the 12th of October, 1897, I notified Mr. Griffen by letter that after Saturday, October 15, the dredge furnished would not longer be allowed upon the work unless another and better dredge be sent to assist.

My circular letter inviting proposals had not been sent to Mr. Griffen as he was not known to be in the business. Although the circular letter had not specified any definite type or capacity of dredge plant, yet I felt that a plant of reasonable strength and capacity was sufficiently implied to consider such requirement a part of the agreement.

On the 12th of October, 1897, the dredge was sunk partly in the channel about 750 feet outside the entrance between the piers. Work was resumed with another dredge November 4 and continued until November 30, during which time the amount removed was 3,965 cubic yards, at 11¼ cents, $455.98.

November 19, 1897, I wrote to Mr. Griffen, the contractor, requesting him to have the dredge removed. A reply was received under date of November 20, 1897, saying he was trying to sell the dredge.

Nothing has, however, been done toward removing the dredge, and on the 17th of May, 1898, I wrote to Mr. Griffen asking if he proposed to remove the dredge, and notified him that unless it were removed within thirty days from that date I should take steps to have it removed by the United States and charge the expenses to his account. To this letter I received no reply.

I therefore ask to be authorized to employ the dredge plant belonging to the United States in this district, with the inspector and crew, to remove the sunken dredge and to complete the dredging of channel as far as may be done with the available funds, to charge the cost of removing the dredge to Mr. Griffen's account, and if there be any balance due him after making that deduction to pay it to him in full settlement of the account.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY.
Washington, June 7, 1898.

COLONEL: Your letter of the 1st instant, in respect to the work of dredging at Monroe, Mich., and removal of wreck near the entrance to the harbor, is received.

It would probably be difficult to compel removal of the wreck of the dredge unless it could be clearly shown that the boat was sunk there through negligence or carelessness of its owner, and it is thought preferable that it be removed under the act of Congress of June 14, 1880, section 4, provided the wreck is such a one as is contemplated by that law. In that event it will be necessary for you to submit an estimate of the cost of the work of removal in order that an allotment may be made under the permanent indefinite appropriation made by that act.

If further work of dredging is required in the harbor it may be done by the United States plant provided funds are available for the purpose.

By command of Brigadier-General Wilson:

Very respectfully, your obedient servant,

A. MACKENZIE,
Lieut. Col., Corps of Engineers.

Col. JARED A. SMITH,
Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, June 10, 1898.

GENERAL: Referring to your letter of June 7, 1898, 26979, regarding the removal of the wreck of a dredge in the channel outside the piers at Monroe Harbor, Michigan, I have the honor to submit the following report, recommendation, and estimate of cost.

About the middle of October, 1897, a dredge employed in deepening the channel at Monroe Harbor, Michigan, was accidentally sunk in the lake about 750 feet outside the end of north pier and directly in the way of vessels approaching the harbor.

The dredge was of little value, and the owner apparently without means to remove it, although requested to do so.

On the 17th of May, 1898, I informed the owner, Mr. M. J. Griffen, of Detroit, Mich., that unless the dredge were removed within one month from that date, steps would be taken to have the wreck removed by the United States.

The wreck is such as to endanger the navigation of Monroe Harbor, Michigan, and of the lake for vessels passing near the harbor entrance; it is therefore of the kind contemplated by section 4 of the river and harbor act of June 14, 1880.

I therefore recommend that the wreck of the dredge be removed by the United States under the provisions of the act above mentioned. The cost of removal is estimated not to exceed $300, if the work may be done by the dredge plant belonging to the United States. If the work is to be done by contract after advertising, the estimate should be increased to $500.

In my opinion, the most economical and advantageous method of removing the dredge, both in point of time and expense, is to do the work by hired labor employing the United States dredge plant and crew for the purpose. I therefore recommend that the work be done in this manner after personal notice of thirty days to the owner.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, June 15, 1898.

COLONEL: Your letter of the 10th instant, reporting the wrecked dredge at entrance to Monroe Harbor, Michigan, to be an obstruction to navigation, is received.

You are authorized to remove the wreck as proposed and the sum of $300 is allotted from the permanent, indefinite appropriation for removing sunken vessels or craft obstructing or endangering navigation—act of June 14, 1880—to pay the attendant expenses of the work.

By authority of the Secretary of War.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers, U. S. Army.

Col. JARED A. SMITH,
Corps of Engineers.

The dredge plant belonging to the United States will therefore remove the wreck at an early date, and the work will doubtless be completed in July, 1898.

M M 13.

SURVEY OF MONROE HARBOR, MICHIGAN, WITH A VIEW OF OBTAINING A 14-FOOT DEPTH OF WATER.

[Printed in House Doc. No. 102, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 2, 1897.

SIR: I have the honor to submit the accompanying report of November 10, 1897, by Col. Jared A. Smith, Corps of Engineers, upon survey

of harbor of Monroe, Mich., with a view of obtaining a 14-foot depth of water, made to comply with requirements of the river and harbor act of June 3, 1896.

The harbor of Monroe has generally been understood to include all that part of Raisin River from the head of the wharves to and into the lake, a total distance of a little more than 2½ miles, and has been improved by the United States, the present depths varying from 9 to 12 feet.

Colonel Smith submits a project for securing 14-foot depth from the lake to the city of Monroe by extending north pier 2,000 feet and south pier 2,300 feet, dredging over bar, canal revetments on both sides, dredging in river and canals, and blasting and removal of rock in situ; estimated to cost, in all, including contingencies, $626,750. He states, however, that this estimate does not include the expense of maintenance, which will be considerable, and that there is no present or prospective commerce which would justify such an expenditure.

In a report on a preliminary examination of Raisin River, dated August 26, 1896, made in compliance with requirements of section 8 of the river and harbor act of June 3, 1896, Colonel Smith stated (see House Doc. No. 81, Fifty-fourth Congress, second session; also Annual Report of the Chief of Engineers, 1897, p. 3094):

> In view of the facts regarding the location, condition, and commerce of the Raisin River, it is my opinion that the cost of any extension of improvement, heretofore planned, would vastly exceed the probable benefit to the commerce of the country. Whatever benefits might accrue would be local in extent, and it is doubtful if even the local benefit would be very great.
>
> The maintenance of the piers, canal revetment, and light-house involves all the expense which can be justified by the present or probable commerce or business of the place.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 10, 1897.

GENERAL: I have the honor to submit the following report of a survey of Monroe Harbor, Michigan, and an estimate of the cost "of obtaining a 14-foot depth of water," as required by section 9 of the river and harbor act of June 3, 1896, and instructions in letter dated July 24, 1896, from office of Chief of Engineers:

In a limited sense, the harbor of Monroe is formed by that part of the Raisin River, Michigan, which is opposite the wharves, which are built only on the south bank of the river, and which extend over a length of about 1,500 feet. The water depth along the upper half of the wharf front varies from 4 to 7½ feet, and along the lower half from 7½ to 8½ feet. The entire width of the river at this place is about 230 feet, and the midchannel has an average depth of 9.3 feet at mean lake level, with a bottom of solid rock. A depth of water less than 14 feet over the rock is found for a distance of nearly 2,000 feet from the upper end of wharves, and for a considerably further distance the rock underlies

the river at depths of 14 to 16 feet. The rock is of a limestone formation and so hard that its removal would be expensive.

In a broader sense, the harbor of Monroe has generally been understood to include all that part of the Raisin River extending from the head of the wharves to and into the lake, a total distance of a little more than 2½ miles. The plan of improvement originally adopted consisted of cutting a canal 100 feet wide and 4,000 feet long through the neck of a marshy peninsula, to make a shorter and better outlet to the lake. At the mouth of the canal piers were extended into the lake, the longer one on the north side being about 1,350 feet in length. A distance of 800 feet from the starting point the piers were parallel and 100 feet apart; thence the directions were changed to widen the space between by an increase on each side to the outer end of south pier, where the width is 210 feet. The north pier extends 200 feet farther into the lake than the south pier.

The sides of canal were protected by a revetment of sheet piling, supported by piles and waling pieces, all of oak.

After the improvement at and near the mouth of the river had been undertaken by the United States the township or city of Monroe further improved the channel by cutting a canal 1,400 feet long across the neck of a peninsula formed by a bend in the river. The city canal had the same width and was protected in the same manner as that constructed by the United States. Approximately, one-half of the channel distance from outer end of piers to upper end of wharves has thus been made in canals entirely outside of the original river bed.

Since 1849 a light-house has been maintained on the outer end of the north pier.

The upper half of the wharf front is but little used and is in poor condition. Along the lower half of wharf front the depths are generally 8 to 9 feet. In the natural bed of the river the depths are 9 feet or more, over a width of 50 to 75 feet. In the canals the mid-channel depths are generally 12 feet or more, decreasing toward the sides. At the outer end of the piers the channel depth is generally a little more than 10 feet.

In November, 1896, a survey of the channel and bar to a depth of 14 feet in the lake was made by Mr. William T. Blunt, United States assistant engineer, and his report was embodied in my annual report for improving harbor of Monroe, Mich., for year ending June 30, 1897 (Report, Chief of Engineers, 1897).

The soundings from the survey have been sufficiently platted to afford means of making an estimate of the first cost of deepening the channel to 14 feet, but as the map is not needed to explain this report its completion has been deferred, to give place for more important work.

Outside of the piers the shortest distance to a depth of 14 feet in the lake is nearly on the prolongation of the axis of channel between piers, and the distance is 2,000 feet beyond the outer end of north pier. Depths of 10 to 13 feet are found on a line bearing north 55 degrees east from the light-house, at a shorter distance than on the prolongation of channel between piers, but the depth of 14 feet is at a distance 600 feet greater than on the direct line. The latter line would expose the channel far less to effects of storms, so that the estimate is based upon that line.

Experience of previous years has shown that channels dredged in the bar outside the ends of piers are soon obliterated by drifting sand, and it is, of course, to be assumed that the requirement of Congress for an estimate of cost of improvement with a view of obtaining a 14-foot

depth of water refers to a channel depth of 14 feet, which can be maintained at a comparatively reasonable expense. A channel across the bar can have no approximation to permanence unless it is protected on both sides by piers. The length of piers required for this purpose on the shortest lines to the lake contour of 14 feet is, for north pier 2,000 feet and for south pier 2,300 feet.

The revetment of the canals is now in very bad condition, and a deepening of channel to 14 feet would remove it entirely, and the banks are too soft to stand well without protection. A new revetment would therefore be required throughout.

The channel across the bar should have a width as great as 200 feet, and if a channel of 14 feet depth were really needed for the business of the place that width should ultimately be made throughout. For the purpose of the estimate, however, a width of 200 feet over the bar and 100 feet inside has been assumed to be sufficient.

These remarks will sufficiently explain the following estimate of cost:

For extending north pier 2,000 feet and south pier 2,300 feet, 4,300 linear feet of pier, at $75	$322,500
Dredging over bar, 51,000 cubic yards, at 15 cents	7,650
Canal revetments on both sides, 10,800 linear feet, at $15	162,000
Dredging in river and canals, 264,000 cubic yards, at 15 cents	39,600
Blasting and removing 19,000 cubic yards of rock in situ, at $5	95,000
Total	626,750

The prices above given are made to include all cost, with contingent expenses, and are as low as they can safely be estimated.

The estimate is for first cost of construction only, and includes no amount for maintaining the channel. That the expense of maintenance will be considerable is apparent from the fact that the natural condition of the river where the bottom is of soft material does not maintain a clear channel of more than 10 feet depth over a width of 50 to 75 feet.

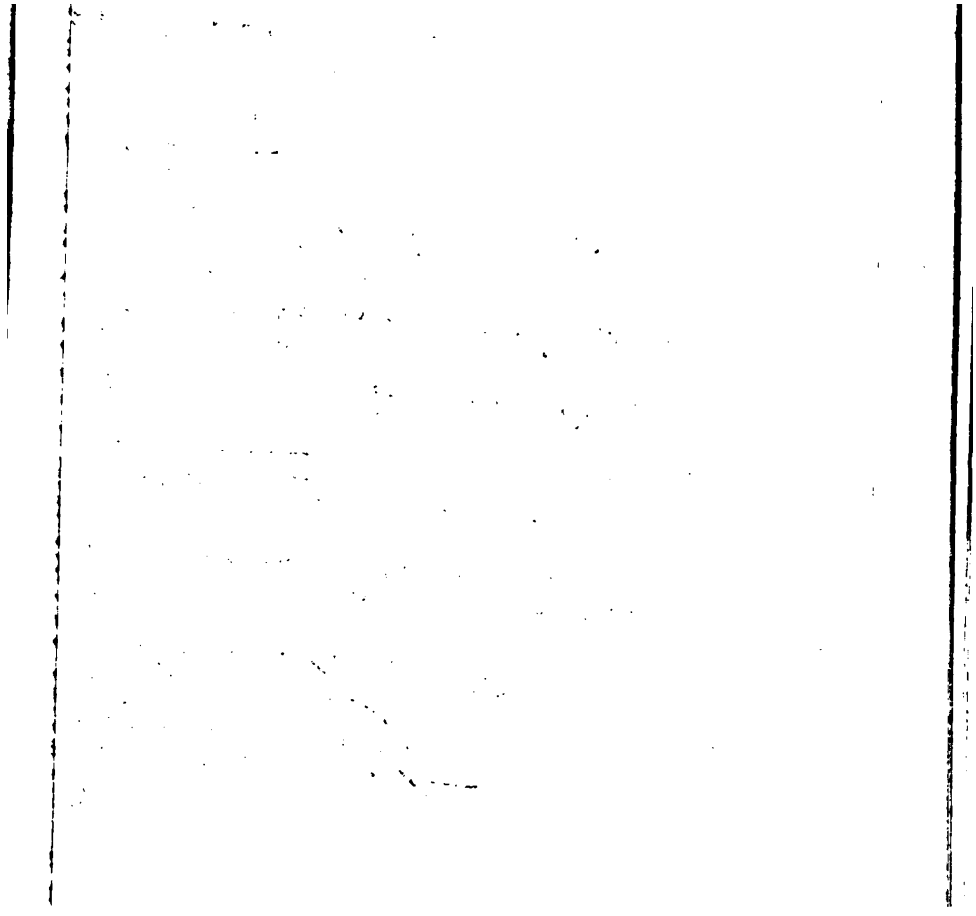
When we look for the present or prospective commerce which would justify such an expenditure it can not be found. Monroe Harbor is located nearly midway between Detroit, Mich., and Toledo, Ohio, both of which have incomparably better facilities by rail as well as water, besides being far better located for receiving and shipping along lines of transportation.

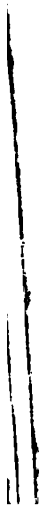
For many years the receipts at the wharves have consisted almost entirely of telegraph poles, of which the calculated weight in 1895 was nearly 30,000 tons. The poles are, however, rafted up the river in tow of tugs which draw less than 10 feet of water.

Within two or three years a small hotel has been built on the shore at the mouth of the river, and clubhouses, bath houses, and other attractions bring business for small excursion steamers running mainly to and from Toledo and carrying people most of whom go and return the same day. These excursion steamers are small, run only during the heated term of summer, and rarely, if ever, go up the river as far as the wharves. Their traffic is not of a kind which affects the commerce of the country at large in any way.

A report of a preliminary examination of the Raisin River was submitted to the Chief of Engineers under date of August 26, 1896, and was published in House Doc. No. 81, Fifty-fourth Congress, second session. I invite attention especially to its closing paragraphs, which are as follows:

> In view of the facts regarding the location, condition, and commerce of the Raisin River, it is my opinion that the cost of any extension of improvements heretofore planned would vastly exceed the probable benefit to the commerce of the country.





Whatever benefits might accrue would be local in extent, and it is doubtful if even the local benefit would be very great.

The maintenance of the piers, canal revetment, and light-house involves all the expense which can be justified by the present or probable commerce or business of the place.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

M M 14.

SURVEY OF THE STRAIGHT CHANNEL IN MAUMEE RIVER AND BAY, OHIO.

[Printed in House Doc. No. 198, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 23, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated December 16, 1897, with maps, by Col. Jared A. Smith, Corps of Engineers, of the results of a survey of the straight channel in Maumee River and Bay, made to comply with provisions of the sundry civil act approved June 4, 1897.

Colonel Smith presents estimates of cost of obtaining a width of 400 feet and a depth of 21 feet at mean level throughout the channels in Maumee River and Bay, as follows:

For river channels	$332,000
For channels and dike in bay	763,000
Total	1,095,000

He expresses the opinion that the channel at the extreme upper part of the wharf frontage, indicated on the map as Division A, is not a thoroughfare and is used only by a portion of the vessels which pass most of the dredged channel below, and as a consequence that a narrower channel here would be sufficient for all necessities of the present or immediate future. If this suggestion is adopted the estimate would be reduced to $1,005,000. Attention is invited to Colonel Smith's remarks regarding maintenance of the work.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, December 16, 1897.

GENERAL: I have the honor to submit the following report of a survey and an estimate of cost of widening and deepening the straight channel in Maumee River and Bay, the duty having been assigned to

me by your letter dated June 10, 1897, in compliance with a requirement in the sundry civil act approved June 4, 1897, as follows:

> The Secretary of War is hereby directed to cause to be made a survey and estimate of cost of deepening and widening the straight channel in Maumee River and Bay, with a view to obtaining and permanently securing a channel of a uniform width of four hundred feet and twenty feet deep at low water, the cost of said survey to be paid out of money already appropriated for the improvement of said channel.

The wording of the foregoing provision of law is such as to admit of some difference of interpretation regarding the extent of the survey and estimate required. In order that the situation may be fully understood, the history and present condition of the improvement of channels in Maumee River and Bay are therefore briefly given in explanation.

As the large maps in detail, platted from the survey and used in computing quantities of material to be removed, are unsuitable to afford a comprehensive view of the river and bay, I have had a map of the river and bay compiled in two sheets upon a smaller scale, and these sheets are forwarded in a separate package to accompany this report.

The harbor of Toledo, Ohio, is in the Maumee River, the greater part of the wharf frontage being on the west side; the upper end of wharf front is nearly 7 miles from the mouth of the river. The unimproved channels in the harbor and thence in the river to the bay were very much deeper than through the bay from the mouth of the river to the lake. At the extreme upper end of the wharf front the depths in a narrow channel exceeded 12 feet; a small shoal near the mouth of Swan Creek had a depth exceeding 14 feet, and a second shoal opposite Riverside Park had depths of 16 feet or more. All other parts of the harbor and of the river below had depths exceeding 18 feet, while in the bay the smallest depths did not exceed 8½ feet, and the channels were so indirect as to add very greatly to the distance from the mouth of the river to deep water in the lake.

The first project for improving the harbor of Toledo, Ohio, was adopted with a view of obtaining a depth of 12 feet in the channels through Maumee Bay. In 1887 a project for a straight channel 17 feet deep and 200 feet wide through Maumee Bay was adopted, in compliance with previous acts of Congress. The estimate of $1,875,000 as the cost of that improvement included the first cost of dredging the channel and of protecting it on both sides by some type of dikes or piers.

The dredging of the channel had been practically completed before the close of the season of 1892; but the deposit from various causes within its banks had added much to the cost of dredging, which necessarily included a considerable amount for maintenance. The construction of the dikes at first proposed has thus far been considered inadvisable.

The original project has been enlarged by increasing the width of the outer part of channel to 300 feet, and by extending the improvement up the Maumee River. The extension in length was in accordance with requirements in the river and harbor acts of July 13, 1892, August 18, 1894, and June 3, 1896. In each of the acts named the improvement has been designated as the "straight channel," and the extension of that improvement up the Maumee River was authorized. While the portions of channel which have been improved in the river can not be considered a part of the straight channel, yet they are additions to the straight-channel improvement of Toledo Harbor which have been specially authorized by law, and it has therefore been assumed that the provision for a "survey and estimate of cost of deepening and widening

the straight channel in Maumee River and Bay" was intended to include such parts of the harbor of Toledo and of the river channels below as had not the depth and width of channel for which the estimate is required.

The depths of water indicated upon charts since 1875 have reference to the plane of mean lake level from 1860 to 1875, inclusive. The stage of low water upon the lakes is very uncertain; while not perceptibly affected by tidal action, the greatest variations of surface elevation in Maumee Bay exceed 12 feet. These extreme fluctuations are mainly caused by very strong winds. Winds from westerly directions are greatest in amount and in force, and they lower the surface in the western part of the lake while raising it in the east. The lowest as well as the highest stages of water are therefore near the extreme ends of the lake, and are of comparatively short duration. The amount of water flowing in and through the lake in a series of years is of course due primarily to the amount of precipitation in the area drained, but the fluctuations of mean as well as of extreme surface elevation are largely due to other causes.

While the conditions have not thus far been exactly determined, there is good reason to believe that the mean annual elevation of the surface in Maumee Bay and in the west end of the lake near its head is several inches lower than in the east end near the outlet into the Niagara River.

For purposes of chart reductions the mean surface elevation of the lake has been assumed to be the same throughout and to be 2.34 feet below the high water of 1838. Cleveland is the nearest point to Maumee Bay where daily records have been kept continuously since 1859. The records from July, 1859, show that in each calendar year the mean monthly elevations have been greatest in the months of May, June, and July, and once only in August. The maximum elevation has occurred most times in June, and more in July than in May. The lowest mean monthly elevations appear most in February, but during the season of navigation they are in November and December. By taking the mean of the low water of each year during thirty-seven years, as shown by the lowest mean stage for a single month in each year, the mean low water at Cleveland is found to be approximately nine-tenths of a foot below the mean level from 1860 to 1875. The mean low water in Maumee River and Bay is probably lower than at Cleveland, and I have therefore assumed that it is approximately 1 foot below the datum plane of mean lake level, and that a depth of 20 feet at low water is as nearly equivalent to 21 feet below mean lake level as can be determined at the present time.

It was required that the cost of the survey should "be paid out of money already appropriated for the improvement of said channel."

The most economical and advantageous method of making the survey was to have it done by an assistant engineer, with the small steamer *Swansea* and crew, which are employed upon improvements in this district, at such times as their services were not imperatively required upon other duties. Under date of June 15, 1897, I therefore assigned the field work of the survey and estimate to Mr. William T. Blunt, United States assistant engineer. A copy of Mr. Blunt's report, dated November 29, 1897, is appended hereto.

The hydrographic work of the survey was carried on at various times from July 2 until October 26, inclusive; it included about 21,000 soundings, each of which had to be located, corrected for reduction to the stage of mean level, and platted upon the charts. The reductions of

soundings and platting of maps have necessarily been made at odd times, in a very small cabin on the steamer, much of the work being done while running from place to place.

The large scale maps of the survey are thus far only sufficiently advanced to furnish data for the estimate, but the smaller maps accompanying the report are better for purposes of explanation.

For full details of the survey and estimate I invite attention to Mr. Blunt's report.

Divisions of the channel on the accompanying maps have been lettered from A to K, for convenience of reference.

The part "A," above Fassett Street Bridge, has not heretofore been improved by the United States. It is at the extreme upper end of the wharf frontage, and of course has less of traffic than is found in the channels below. I believe that, while the greater width is desirable, all purposes of business would be reasonably served with a width of 200 feet and a turning basin of 500 feet width at the upper end. This would somewhat reduce the estimate of quantities.

Division "B," between Fassett Street Bridge and the bridge of the Lake Shore and Michigan Southern Railway Company, has a channel exceeding 21 feet in depth, with an average width of at least 400 feet, though in places it is a little less. I believe that this portion of the channel sufficiently fulfills the requirements for a depth of 21 feet at mean lake level and a width of 400 feet, so that no estimate for its widening is included.

The part marked "C," from bridge of the Lake Shore and Michigan Southern Railway Company to the Cherry Street Bridge, a distance nearly 1½ miles, covers the shoal heretofore dredged 400 feet wide and 18 feet deep over a length of nearly 4,000 feet. The deeper channel will necessarily have to be dredged over a slightly increased distance, and it is considered advisable to modify the location of a part of the lower end.

The part "D," between Cherry Street Bridge and the bridge of the Pennsylvania Railroad, has a channel depth exceeding 21 feet and nearly 400 feet wide. This is a busy place for navigation on the city front, and its limitations by the bridges make the full width all the more desirable.

Divisions "E," "F," and "G" cover the channel between the Pennsylvania Railroad Bridge and the bridge of the Wheeling and Lake Erie Railroad, more than 2 miles below. Nearly midway between the two bridges is the shoal known as "The Crossing," which has been dredged to a depth of 18 feet over a width of 400 feet and a length about 3,500 feet.

The part "H" completes the river channel to the head of the straight channel in the bay. From this point to the contour of 21 feet depth in the lake the distance is a little more than 8 miles, which is essentially a straight channel throughout, but which has a small place near the middle, known as "The Turn-out," where the channel is divided into two parts of 200 feet width each, with a space between where range lights are located in the axis of the channel. Near each end of this place there is a large crib filled with stone, on which are light-house beacons.

At the southwest end there is a dwelling for light keeper, a good wharf, and a buoy shed for the Light-House Establishment. An iron light-house is now being constructed at each end, so devised as to make a range in both directions in the axis of the channel. The middle of channel is also marked from the mouth of the river outward by beacons, known as the "Manhattan Range," at North Toledo.

per and light station at the outer beacon a dike or other ter-
ans of communication between the two lights is essential to their
and reliable maintenance. The distance to be traversed in a
oat is about one-fourth of a mile, exposed on all sides to winds
s from the lake and bay, and at certain seasons to ice, with no
whatever at the outer beacon, and but little at the main light.
l dike between the lights will protect both adjacent channels
oss currents and the resulting inconvenience and fill, and will in
protect one of the channels from seas; it will also be a guide
ing vessels, and will prevent them from going aground between
its. The other benefits to be derived from the construction of
e are in connection with the maintenance of the lights and the
s it will afford for a storage depot. I therefore recommend its
ction as a necessary part of the work.

Blunt has discussed the question of maintenance of channels
ie basis of the fill which has heretofore taken place. Upon that
he estimated annual cost of maintaining the channels to full
nd depth, for which the estimate is made, is $50,450. It is my
that after the channels have been fully excavated the quantity
erial which will fill into them will be less than the estimate, more
lly in the bay, where a different principle is involved from that
n river channels. The Maumee River itself is quite different
vers in general. The surface of the river is not maintained by
ount of outflow throughout most of the year, but is held at practi-
e same mean elevation as the lake. The sectional area of the river
and the outflow in general very small. When winds are such
ise the water level in Maumee Bay, the water flows up the river,
case of a very rapid lowering in the bay the water flows outward
velocity not in the inverse ratio of the area of wet cross section,
ost rivers, but it is quite possible that in the bay, and in parts
river, the currents may under certain conditions flow more
in a large channel than in a small one, because of the decreased
ice.

e annual report on the straight-channel improvement for 1896,
of Chief of Engineers, 1896, page 2919, the tables accompany-
report are discussed, with the conclusion that—

ter sections there will be little, if any, more actual fill in a wide channel
narrow one, and that with a wide channel once obtained the cost of main-

a distance of about five-eighths of a mile in the outer end of straight channel, there was an average increase exceeding 5 inches in the channel depth. In the previous year the soundings over same section of channel showed an average shoaling of nearly 4 inches.

In the dredged river channels as well as in the bay the fill is doubtless largely due to the sliding in of surface material of the banks and bottom of adjacent shoals. It is evident that this source of reduction in channel depths will be less from year to year, so that in a few years the amount will be too small to be considered.

A continued study of the conditions and observations in the river and bay leads me to believe that the excess of fill heretofore found in the parts of straight channel nearest the river, or even in the river itself, over those nearer the lake is not entirely due to deposition of silt which has been brought down the river, but that further observations will show that this excess is partly due to the different character of material in and near the banks of the dredged channels.

The banks in and near the river are of clay or mud, of which the surface is soft and easily stirred up by currents or passing vessels, while in the outer part of channel the surface is generally of sand, which overlies a harder material than that in the river. The wider the channel is made the less the banks will be disturbed by passing vessels.

While the estimate of annual fill given in Mr. Blunt's report is based upon certain data to which he refers, yet underlying those data are to be found principles of operation which show that the amounts of fill in any section do not bear any fixed ratio to the channel widths, and that the rate of fill and consequent cost of maintenance after the channel has been completed is not likely to be uniform, but will decrease from year to year. The work of maintenance can be done with greatest economy and advantage by a dredge plant belonging to the United States.

During the fiscal year ending June 30, 1896, the entire cost of maintaining and operating the United States dredge, tug, and scows employed upon the improvement, which included quite as much as the annual average amount for repairs, did not exceed $18,000. It is my opinion that after the channels have been completed and maintained three to five years, when the banks will have become reasonably permanent, a dredge plant which can be maintained and operated at a cost not exceeding $20,000 per year will be sufficient to maintain the dimensions of channels, and, in addition, at times to be made useful elsewhere. During this intermediate period between completion and stability the expense may be reasonably assumed not to exceed an average of $30,000 per year.

To confine the channel throughout by jetties or other works with a view to maintaining the depths by the scour of currents would require a vast expense for original construction of works, which would still afford no certainty of permanence without further cost. Such a method is, therefore, not to be recommended.

The price per cubic yard in the estimate submitted by Mr. Blunt for the dredging in the river is probably larger than that at which the work may be let by contract under reasonably large appropriations. The price per cubic yard for dredging in the river will generally be larger than for work in the bay, because of the greater distance to which the material must be towed and of the greater average depth of cutting in the bay. Part of this work may be done by the dredge plant owned by the United States, and the work thus accomplished will cost much less than the estimates.

I have, therefore, reduced the estimates of cost per cubic yard, and in the river have arranged the prices somewhat in relation to distances from the bay.

With these explanations I submit the following estimate:

FOR RIVER CHANNELS.

[Dredging, scow measurement.]

Division A, 745,000 cubic yards, at 22 cents	$163,900
Division C, 180,000 cubic yards, at 20 cents	36,000
Division D, 15,000 cubic yards, at 20 cents	3,000
Division E, 116,000 cubic yards, at 20 cents	23,200
Division F, 96,000 cubic yards, at 18 cents	17,280
Division G, 70,000 cubic yards, at 18 cents	12,600
Division H, 290,000 cubic yards, at 16 cents	46,400
Contingencies of office, engineering, etc.	29,620
Total	332,000

While my opinion on any part of this estimate is not required, yet I feel justified in inviting attention to the fact that the channel at the extreme upper part of the wharf frontage, indicated as Division A, is not a thoroughfare and is used only by a portion of the vessels which pass most of the dredge channels below. A much smaller width would be sufficient for all necessities of the present or immediate future, and an expenditure of one-half the estimate in that division would be as much as present conditions appear to justify.

This would reduce the estimate for first cost of widening and deepening river channels as follows:

Dredging river channels	$220,450
Contingent expense of all kinds	21,570
Total for river channels as modified	242,000
For dredging straight channel in Maumee Bay, 4,970,000 cubic yards, at 12½ cents	621,250
Contingencies of all kinds	61,750
Total straight channel	683,000

FOR DIKE BETWEEN TURN-OUT CHANNELS IN MIDDLE OF STRAIGHT CHANNEL.

The estimate in Mr. Blunt's report will, I believe, be found too small. I therefore estimate the cost to be the same as that of a pier of crib work and stone.

1,000 linear feet, at $80 per foot	$80,000

The total estimated cost for obtaining the width of 400 feet and a depth of 21 feet at mean level throughout the channels in Maumee River and Bay is summarized as follows:

For river channels	$332,000
For channels and dike in bay	763,000
Total	1,095,000

If the part of channel at the extreme upper end, Division A, be made narrower, as suggested, the estimate will be:

For river channels	$242,000
For bay as before	763,000
Total	1,005,000

The estimate in 1887 for a straight channel in Maumee Bay 200 feet wide and 17 feet deep at mean lake level was, as already stated in this report, $1,875,000, upon the basis of protecting the channel by dikes.

Although the work was practically completed in 1892, and has since been widened to 300 feet in outer section, extended to cover two shoals in the river, and has been maintained five years with the depths somewhat increased as a factor in future maintenance, the unappropriated balance of the original estimate is $980,000. It will be seen that the unappropriated balance of the estimate made ten years ago for a channel 200 feet wide and 17 feet deep, protected on the sides in the bay only, is considerably more than the estimate now made for a channel of more than twice that capacity in the bay, but having no protections on the sides. Even with the improvement of the river channels added, the increase of former estimate is very small.

Mr. Blunt refers to the additional cost for each year of delay in completing the improvement, and estimates the amount to be $23,000. It is evident that the cost of maintaining the depths over parts previously completed will be inseparable from the expense of construction until the channel has been once completed, when all further work will, of course, be for maintenance only. There are so many variable and undetermined elements entering into the problem of maintenance of the channel depths, both before and after the full dimensions have been obtained, that it is quite impossible to obtain a solution which shall be correct beyond question or possible necessity for future revision. Mr. Blunt's estimate for cost of maintenance previous to completion is as nearly correct as it can be made from data now available.

The requirement that the estimate of cost shall be "with a view to obtaining and permanently securing a channel" of the dimensions given adds to the estimated cost of construction that of subsequent maintenance.

This part of the subject has already been discussed, with the conclusion that permanent dikes over so great a distance under conditions here existing are not practicable as a matter of economy or certainty of operation. Maintenance of the channels by dredging was estimated not to exceed $150,000 in five years after completion and an annual cost of $20,000 thereafter, provided the work is done by a good plant belonging to the United States.

The fill from sliding in of banks may very properly be provided for by a slight additional width in advance, and perhaps also an additional depth in the outside cuts, thus providing for part of the fill in the channel before it has occurred.

Should this improvement be made to the channels in Maumee Bay and River, the purchase or construction of an additional dredge, tug, and scows specially adapted for this work and for other dredging on Lake Erie would be economical and advantageous to the United States. Such a plant could do much of the dredging at an expense which would doubtless save more than its cost, and would leave it available to assist in maintenance and for service at various other harbors in this district where small amounts of dredging are required every year. At these harbors the time of year, location of work, immediate necessity, and small amount are such that it is generally impossible to obtain the necessary relief promptly and cheaply.

The location of Toledo is such that the maintenance of good channels is of much importance. In 1876 the registered tonnage of vessels entering and departing at Toledo Harbor was 860,359 tons. In 1886, after a period of ten years, the registered tonnage was 846,792 tons.

TOLEDO, OHIO, *November 29, 1897.*

n accordance with your orders of June 15, 1897, I have the honor to submit
ı a report of "survey and estimate of cost of deepening and widening the
channel in Maumee River and Bay, with a view to obtaining and perma-
ɔcuring a channel of a uniform width of 400 feet and 20 feet deep at low
he cost of said survey to be paid out of money already appropriated for the
ment of said channel," as called for in sundry civil act of June 4, 1897.
appropriation was made for the work, it was necessary to use the regular
making the surveys at such times as could be spared from the routine and
cy work always on hand. Work was begun July 24 and concluded as far as
ble October 26. During this period about 21,000 soundings were taken.
ter division of straight channel soundings were carried 900 feet on each side
so that if any protection works should be needed the depths will be at hand.
e remainder of channel the lines were carried 400 feet each side of axis.
r mouth at entrance to straight channel was covered completely, as was the
finished portion of lower crossing in the river. The site of the old Union
ust below the Lake Shore and Michigan Southern Railroad Bridge, was care-
ınded to determine the amount of obstruction remaining there. Over the
er of the river time did not allow of resounding, but the changes since the
e survey of 1892 have been slight. This survey extended only as far up as
e Shore Bridge, so that above that bridge it is necessary to use the sound-
en by the city engineer of Toledo some years since, which appear to have
efully taken and located.
'ording of the act calling for this estimate names 20 feet depth at low
All published charts and all harbor work in this district are based on the
vel of Lake Erie for the years 1860 to 1875, inclusive. This level is the mean
vels, summer and winter, during those years, and is practically identical
e mean level from 1860 to 1895. The term "low water" is so exceedingly
ie when applied to Lake Erie that it is difficult to determine its meaning.
direction, however, it is assumed to be 1 foot below the mean level men-
bove, and the estimate is therefore based on a depth of 21 feet at mean level,
aining "mean level" as a basis for all figures given.

DIVISION AND DESCRIPTION.

stimate is divided into "portions," beginning at the Schenck coal wharf
tered consecutively out to the lake. The conditions holding in each and
ion of proposed work are as follows:
n *A*.—Extends from Schenck coal wharf to Fassett Street Bridge, 5,900 feet.
e, bank to bank, at upper end, 2,400 feet; at lower end, 700 feet, with estab-
ıarbor lines near shores. Through wider part, and to within 500 feet of the
extends a middle ground, with water 4 to 5 feet deep and a narrow natural
of probably 10 to 12 feet depth originally along each shore.
ght bank, the only commercial wharf is that of the Cincinnati, Hamilton
rton Railroad elevator, about 500 feet above the bridge. On left bank lum-
l. and elevator wharves are built, the Schenck coal wharf being the upper-

good 21-foot channel exists throughout from 300 to 500 feet wide, with maximum depths of 21 to 27 feet.

The proposed channel is parallel to harbor lines and to a line connecting the ends of drawpiers of the two bridges. Dredging will be all on right bank of channel and small in amount.

Portion C.—Extends from Lake Shore and Michigan Southern Railroad Bridge to Cherry Street Bridge, 7,700 feet; width of river, 700 to 900 feet. Natural 21-foot depth carries from Lake Shore and Michigan Southern Railroad Bridge to 3,000 feet below it for a width of over 400 feet, with maximum depths of 21 to 25 feet. Twenty-one feet is again found at Cherry Street Bridge, but not for full width. The intermediate distance has been recently dredged by the United States to about 19 feet, 400 feet wide.

About 1,000 feet below Lake Shore and Michigan Southern Bridge, where the old Union Bridge stood, there remain portions of the old piers in deep water. On them is now found but 16 to 18 feet of water, and they are in such shape that an accurate estimate is not practicable. I have therefore assumed that the removal will cost $1,000.

To conform more nearly to the new harbor lines established since dredging, I recommend changing the location of the angle in dredged channel so that it shall be at Jefferson street instead of at Monroe street. Material is sand and mud entirely.

Portion D.—Extends from Cherry Street Bridge to Pennsylvania Railroad Bridge, 1,800 feet; width between harbor lines, 900 feet. A good natural 21-foot channel now exists, with maximum depths of 21 to 26 feet, but it will require widening on the right bank. Edge of proposed channel, 50 feet from harbor line on left bank. Material, sand and mud.

Portion E.—Extends from Pennsylvania Railroad Bridge to south line of Ash street, 4,700 feet. Banks 1,700 to 2,000 feet apart. Natural channel follows the wharves on left bank. Twenty-one feet depth carries from bridge, where it is 400 feet wide, to about 1,800 feet below, with maximum depths of 21 to 28 feet. For the remainder of the distance depths are now 18 to 20 feet.

The proposed channel is parallel to harbor line on left bank and 50 feet therefrom. Material is sand and mud, and dredging will consist of widening and deepening.

Portion F.—Extends from south line of Ash street to the south line of large wharf at Craig shipyards, 3,000 feet; width about 2,000 feet, bank to bank. This portion covers a crossing of the river by the natural channel from left bank to right bank. It has always been shoal, with flats on each side; has recently been dredged by United States, and now has an average depth of 19.3 feet 400 feet wide.

Lines of channel will be in direct continuation of those in Portion E, and will change direction at junction with Portion G, edges being 50 feet from harbor line at each end of portion. Material, sand and mud. Dredging will consist entirely of deepening.

Portion G.—Extends from Craig shipyard to Wheeling and Lake Erie Railroad Bridge, 3,700 feet; width about 2,600 feet between banks. A good 20-foot natural channel follows right bank, with maximum depths of 20 to 22 feet for nearly the whole length, but narrower than 400 feet, and only a small part being 21 feet. Proposed channel centers on railroad bridge draw. Dredging will consist principally in widening.

Portion H.—Extends from Wheeling and Lake Erie Railroad Bridge to straight channel entrance at end of section 15, inner division, 9,700 feet. A good natural 21-foot channel now exists for 6,000 feet below bridge, though quite narrow in places, with maximum depths of 21 to 29 feet. This channel is now on a slightly reversed curve, bending westward around Grassy Point toward the old channel in Manmee Bay.

Proposed new channel is straight from the bridge to the Ironville wharf (north line of Michigan street), with its easterly edge 150 feet from harbor line on right bank, thence straight and parallel to the present limit of bell mouth dredging, 150 feet therefrom until it enters the straight channel. On the left bank it cuts decidedly into the Grassy Point Flats, so as to correct to a large extent the tendency toward the old channel and lessen the change of course from river to straight channel. Material is sand and mud, with some clay underneath in places.

Portion I.—This covers the inner division of straight channel, 12,000 feet long, divided into 15 sections of 800 feet each. Channel is now dredged 200 feet wide at bottom and has an average depth of about 17½ feet, with bank depths of 5 to 8 feet.

Dredging will consist of deepening the present width and of widening 100 feet on each side. Material is clay at inner end, with sand and mud on top, while beyond the vicinity of Presque Isle it is largely sand, mud, and gravel, with clay underneath.

Portion J.—This covers the middle division of straight channel, 11,640 feet long, divided into sections of 800 feet each, with a part of a section at inner end. It extends from the outer end of Portion I to the main crib light. Channel is now dredged 200 feet wide at bottom, and has an average depth of about 17½ feet, with bank depths of 8 to 11 feet.

Dredging will consist of deepening the present width and of widening 100 feet on each side. Material is sand and mud, with some clay underlying. For the last 1,000 feet the widening will gradually reduce to nothing, as the "turn-out" around cribs will not be widened.

Portion K.—This covers the outer division of straight channel, 20,800 feet long, divided into 26 sections of 800 feet each. The first 2,000 feet of this division comprises a double "turn-out" around cribs, 400 feet wide in the aggregate, and will not be widened. For remainder of division the channel is now 300 feet wide at bottom, and has an average depth of 17½ feet, with bank depths of 7 to 11 feet for half its length, thence gradually deepening to the lake.

Dredging will consist of deepening the present width and of widening 50 feet on each side except on the 2,000 feet of "turn-out," where the widening will gradually reduce to nothing. Overlying material is sand and silt, and the clay substratum slopes gradually from a depth of 11.3 feet at cribs to 17 feet depth, 1,700 feet outside of cribs.

Portion L.—Island at cribs.—The two crib lights, so called, are located on the axis of the straight channel, near the middle of its length, and are about 1,000 feet apart. A keeper's dwelling and one light are on the main or inner crib and a second light on the outer crib. To reach this outer crib the keeper is obliged to cover the distance in a small boat, a trip often perilous and at times impossible. In passing around these lights the two turn-out channels are separated by a distance of about 120 feet. Some years ago a skeleton structure of piles was built 80 feet wide extending from crib to crib, but the original plan of making this an island was never carried out. At present the piling is utterly wrecked, except around the cribs themselves, where it is in good condition. Twice has the attempt been made to throw over material from the adjacent dredging without protection, and failure has resulted in each case, the material rapidly washing away. I have now made estimate for a stone protection and for filling the entire area to a height of 8 feet above mean level.

EXPLANATION AND ESTIMATE.

All cuts are estimated to a depth of 21 feet at mean level, for reason given early in this report. Side slopes are estimated at 1 on 1, or 45°.

In table below is a brief description of each portion. The first column shows the estimated neat quantity of material to be removed as it lies in place, with no allowance for extra depths, always necessary to obtain the minimum required, nor for excess of measurement after placing in scows.

The second column shows the quantity after adding 20 per cent to the neat estimate. I believe this will cover all contingencies of the character mentioned.

The third column shows price per yard, scow measurement, which I consider as the highest reasonable cost. I have averaged the entire river work at 25 cents and the bay work at 12½ cents. I believe these prices may be reduced 20 per cent on competitive bids; possibly more, should the work be let on the continuous-contract plan.

The fourth column shows cost in dollars on the basis of preceding columns.

Estimate of quantities and cost.

Portion.	Description.	Neat measurement in bank.	20 per cent added in scow.	Price.	Cost.
		Cubic yds.	*Cubic yds.*	*Cents.*	
A	Schenck coal wharf to Fassett Street Bridge	620,700	744,800	25	$186,200
B	Fassett Street Bridge to Lake Shore and Michigan Southern R. R. Bridge	4,200	5,000	25	1,200
C	Lake Shore and Michigan Southern R. R. Bridge to Cherry Street Bridge	148,800	178,600	25	44,600
D	Cherry Street Bridge to Pennsylvania R. R. Bridge	11,100	13,300	25	3,300
E	Pennsylvania R. R. Bridge to Ash street	96,600	115,900	25	29,000
F	Ash street to Craig shipyard	79,600	95,500	25	23,900
G	Craig shipyard to Wheeling and Lake Erie R. R. Bridge	56,800	68,200	25	17,000
H	Wheeling and Lake Erie R. R. Bridge to straight channel	241,000	289,200	25	72,300
I	Inner division, straight channel	1,570,000	1,884,000	12½	235,500
J	Middle division, straight channel	1,236,600	1,483,900	12½	185,500
K	Outer division, straight channel	1,335,000	1,602,000	12½	200,300
	Total	5,400,400	6,480,400	.....	998,800
	Office and engineering contingencies, 10 per cent	.....	.....	.....	99,880
	Total estimated cost of dredging	.....	.....	.....	1,098,680

ISLAND AT CRIBS.

[Portion L.]

15,400 tons pier stone, at $1.33⅓	$20,53
9,500 tons riprap stone, at 75 cents	7,12
Rehandling 40,000 yards of filling, at 20 cents	8,00
Grading	30
	35,95
Office and engineering contingencies, 10 per cent	3,59
Total estimated cost	39,55

The above estimate covers the first cost of the work under conditions prevailing at present. In portions of the channels where natural conditions prevail there is no indication of shoaling water from year to year, but where these conditions have been changed by dredging the tendency is more or less marked toward a reestablishment of the original conditions. I beg leave to refer to my report of June 30, 1897, in regard to the annual deposits found to take place in the dredged channels, and to deduce therefrom the probability that in such channels we may look for an average annual deposit of one-third of a foot in the bay channels and one-quarter of a foot in the river channels after they have been once dredged.

Upon this basis the original estimate will be increased by each year's delay as follows:

Portion C, 16,000 yards, at 25 cents	$4,000
Portion F, 11,000 yards, at 25 cents	2,750
Portion I, 30,000 yards, at 12½ cents	3,750
Portion J, 30,000 yards, at 12½ cents	3,750
Portion K, 70,000 yards, at 12½ cents	8,750
Total	23,000

Upon the same basis the annual cost of maintenance after once being dredged will be—

Portion A, 20,400 yards, at 25 cents	$5,100
Portion B, 400 yards, at 25 cents	100
Portion C, 16,000 yards, at 25 cents	4,000
Portion D, 1,800 yards, at 25 cents	450
Portion E, 11,000 yards, at 25 cents	2,750
Portion F, 11,000 yards, at 25 cents	2,750
Portion G, 13,800 yards, at 25 cents	3,450
Portion H, 17,000 yards, at 25 cents	4,250
Portion I, 59,200 yards, at 12½ cents	7,400
Portion J, 59,200 yards, at 12½ cents	7,400
Portion K, 102,400 yards, at 12½ cents	12,800
Total	50,450

Comments.—I wish specially to note the possibility that the conditions may attract bids from owners of hydraulic dredges, especially in the river, where the material is entirely adapted to that process and where the recently established harbor lines are causing shore owners to study the advisability of building to these lines in the near future. There is no question that if the filling can be obtained by pumping through pipe outlets onto the flats without expense to the owners many of them would build the necessary bulkheads to retain it. Should this be the case, the cost of the river dredging might be reduced 50 per cent.

The limits of extension up the Maumee River are left indefinite in the call for estimate. While in the past the United States has done some work on the river far above the limits of Toledo wharves, it has in recent years of increasing size of vessels never gone above the Lake Shore and Michigan Southern Railroad bridge. The river above Toledo is never used by modern boats. The portion within the limits of Toledo covered under heading A in estimate is used quite extensively, but almost entirely by medium-sized boats, for which the width and depth named in the act are not required. I should judge that above Fassett Street bridge a cut 100 feet wide and 21 feet deep will be ample for some years, and may be enlarged later as justified by commerce.

Along some portions of the natural channel the estimate covers small amounts to be removed from one edge or the other in order to obtain the actual 400 feet width. Some of these can as well remain untouched, but, as they are small in comparison to the total, little will be gained.

The large maps of soundings in detail have not been fully completed. They are

[redacted]

[redacted]

[redacted]

essary to the intelligent consideration of the subject, and will be placed on
ioon as possible.
res me pleasure to record my appreciation of the energy and good judgment
ed by Captain Stevenson, master of steamer *Swansea*, in obtaining the large
r of soundings in the midst of other work. It is only by taking full advan-
all favorable conditions of weather, early and late, that such results can be
ed with a crew whose time would really be fully occupied without the extra

Very respectfully,

WM. T. BLUNT,
United States Assistant Engineer.

JARED A. SMITH,
Corps of Engineers, U. S. A.

M M 15.

EY OF STARVE ISLAND REEF, NEAR SOUTH BASS ISLAND, IN LAKE
E, OHIO, WITH A VIEW TO OBTAINING A NAVIGABLE CHANNEL
ENTY-FIVE FEET IN DEPTH OVER SAID REEF.

[Printed in House Doc. No. 103, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 1, 1897.

: I have the honor to submit the accompanying report of Septem-
5, 1897, with map, by Col. Jared A. Smith, Corps of Engineers, of
sults of a survey of Starve Island Reef, near South Bass Island,
ke Erie, with a view to obtaining a navigable channel 25 feet in
over said reef.

s survey was made to comply with requirements of the river and
r act of June 3, 1896, and from the data secured Colonel Smith
ates the cost as follows:

moving all rock above grade of 21 feet	$258,300
moving all rock above grade of 25 feet	761,250

ransmitting this report to this office Colonel Smith remarks:

he time this survey was required by Congress in the act of June 3, 1896, there
many reasons for believing that the removal of the reef would be attended with
pense and greater benefits than are now estimated. For the reasons set forth
report, I do not consider that the interests of commerce involved are sufficient
ify the expense, and it is therefore my opinion that the proposed improvement
worthy of further consideration.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

n. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, September 15, 1897.

ERAL: I have the honor to submit the following report upon a
y of "Starve Island Reef, Ohio, near South Bass Island, in Lake

Erie, with a view to obtaining a navigable channel 25 feet in depth over said reef."

This survey was required by section 9 of the river and harbor act of June 3, 1896, and by letter from office of Chief of Engineers, dated September 5, 1896, which allotted for the purpose the sum of $500 from appropriation for "examinations, surveys, and contingencies of rivers and harbors," all of which has been expended.

It was near the middle of October, 1896, before the small steamer employed upon river and harbor work in this district could be spared for the purpose, but, when once commenced, the hydrographic work of the survey was laid out and completed in two days—October 14 and 15. It was, however, past the middle of March, 1897, before the assistant engineer, who had made the survey, could complete the original map, a tracing of which is forwarded in a separate roll to accompany this report.

Mr. William T. Blunt, United States assistant engineer, to whom the duty of making the survey was assigned, submitted a report under date of March 19, 1897, which is appended hereto, and to which I invite attention regarding the details of the survey and to his remarks upon the policy of making the improvement.

Upon the same sheet which contains the chart of the reef, on a scale of 1:1000, is a tracing of a part of Lake Erie Coast Chart No. 6, to show the location of the reef and of certain rocks discovered by examinations under direction of this office in the summer of 1896.

The buoy upon the reef is nearly 2,000 feet to northeast of the chart course for vessels passing between the south shore of the lake and South Bass and Kelley islands. The reef has always been considered a great danger to vessels, especially in thick weather, when the lights at Marblehead and Green Island could not be seen. A new light-house has recently been completed and a light shown from the south-east point of South Bass Island, which, when ranged with the light on Green Island, forms a line passing southeast of the reef at a sufficient distance to avoid danger. A large element of danger from the reef has therefore been removed by the new light.

In July, 1896, an examination in the area bounded by Kelley Island, Bass Island, Catawba Island, and Marblehead developed the fact that there are many rocks not far from this channel where the mean depth of water is less than 18 feet at points not shown upon the charts. Mr. Blunt refers to this fact in his report, and very properly remarks that "while these unlocated obstructions remain they are a greater menace to navigation than is this reef, which is well located and marked."

It has also been ascertained that if this reef were removed to a depth of 25 feet it would not result in giving a clear channel of that depth throughout, because, in addition to the rocks before mentioned, there is a considerable area directly in the course of vessels where the depths range from 21 to 24 feet.

It is therefore apparent that the removal of Starve Island Reef to a greater depth than 21 feet would not result in any great benefit unless taken in connection with a general clearing away of rocks and increase of depth over a very considerable additional area.

Considering the character of the reef, which is a hard limestone having very irregular surfaces of cleavage when blasted, I believe that the price of $5 per cubic yard will hardly cover more than the contract price of removing the rock, to which should be added about 5 per cent for contingent expenses of office and engineering.

Total	761,250

ne-half the estimated cost of removal to a depth of 21 feet would ufficient to build a good light-house upon the reef, and the interest he other half at 3 per cent would probably exceed the average ual cost of maintaining the structure and exhibiting the light. h a light-house, if built, would be worth more to navigation than removal of the reef. Since the construction of the light station on th Bass Island, the construction of a light-house on Starve Island f has not been urged, and it is probable that the present need would justify the great expense.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

rig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. WILLIAM T. BLUNT, ASSISTANT ENGINEER.

TOLEDO, OHIO, *March 19, 1897.*

R: I have the honor to file herewith a map of Starve Island Reef, Lake Erie, survey made in October, 1896, and to report as follows upon the same:
accordance with your orders of September 7, 1896, the survey was made at the opportunity, but it was October 14 before time could be spared from other work vorable weather. By hard work the survey was completed on the 14th and 15th out serious interference from winds, which were very heavy both before and those days.
e general area of reef was first inclosed by trial sounding so as to properly cover ranges. A base range was selected, using well-defined shore marks, sounding were laid out at right angles to it, and location ranges parallel to it, all by ful measurements with wire line. Sounding lines were 25 feet apart and ranges et apart, marked by buoys floated to stand plumb. Soundings were taken from all boat with a rod marked to tenths of a foot, the boat being rowed along a and soundings taken as fast as a man could handle the rod. Usually they are t 10 feet apart along the line, and being located at the crossing of each range, error in location of any sounding is exceedingly small. Upward of 2,500 dings were taken, and are shown on map reduced to mean level of Lake Erie, -1875, and contoured at each foot of depth. General location with reference to

chart course clears this buoy 1,700 feet, and a vessel can not deviate greatly t north or south of this course without passing into dangerous water. The least d immediately north of the buoy is 13½ feet and the shoalest part of the entire r 250 feet northerly from the buoy, with a depth of 10 feet. The material seems solid limestone rock of irregular surface, and covered with sand around the ed about 22 feet depth.

On account of the nature and location of the reef its removal will be quite e sive. The lowest price at Lime Kiln Crossing was $4.43 per cubic yard in While that location had the disadvantage of strong current and continual pa of boats, these would be more than counterbalanced by the disadvantages h exposed location, longer tow for dumping, deeper digging, and very large ext shoal cutting. I believe a fair estimate of cost by contract would be $5 per y situ.

The following table shows the amount of material above the various de those outside the limits of survey being estimated, and I believe below the a amounts, and the cost of removal to the various depths at $5 per yard:

Limit of area.	Area.	Average cut.	Cubic yards in situ.	Maximum cut.	C
	Sq. feet.	*Feet.*		*Feet.*	
20-foot curve	275,000	2.97	30,200	10	$1
21-foot curve	375,000	3.54	49,200	11	1
22-foot curve	471,000	3.71	64,800	12	1
23-foot curve (partly estimated)	640,000	3.60	85,400	13	1
24-foot curve (estimated)	890,000	3.40	112,000	14	1
25-foot curve (estimated)	1,230,000	3.18	145,000	15	1

In considering the question of the removal of this reef, it is well to reme that investigations of last season, even though far from complete, developed rocks with less than 18 feet over them in close proximity to this south cha where the Lake Survey Chart shows clear bottom with 3½ to 5 fathoms. This at all surprising, since that survey was made only for general depths. Many of rocks are detached, isolated bowlders on an otherwise perfectly clear sand bo and it can not be expected they will be found except by an exhaustive sweepi the whole area.

While these unlocated obstructions remain they are a greater menace to na tion than is this reef, which is well located and marked; and their location removal would seem to be of large benefit to navigation and at comparatively cost. I beg to suggest, therefore, that it is inadvisable to entirely remove thi until a systematic scheme for the clearing of the entire passage is entered upon a rigid and extensive examination; and until it shall be advisable to remove th to the full depth recently adopted for main channels—i. e., 20 and 21 feet—it w not be advantageous to remove it to a less depth, with the possibility of going the same area again at some future time.

As soon as the light-house on the southwest point of South Bass Island is pleted the clearance of this reef will be well marked by the range of the new and that on Green Island.

Very respectfully,

WM. T. BLUNT,
United States Assistant Engin

Col. JARED A. SMITH,
Corps of Engineers, U. S. A.

M M 16.

SURVEY OF BAR AT THE MOUTH OF SANDUSKY HARBOR, OHIO.

[Printed in House Doc. No. 362, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, March 17, 189

SIR: I have the honor to submit the accompanying copy of repo February 28, 1898, with maps, by Col. Jared A. Smith, Corps of E neers, giving the results of a survey of the bar at the mouth of

Harbor, together with estimate of cost of improvement, with a
o securing and maintaining a permanent navigable channel of
ent depth next to Cedar Point, made to comply with requirements
river and harbor act of June 3, 1896.
locality is now being improved by the General Government
a project which provides for the construction of a jetty from
Point into the lake with a view to extending the Deep Hole chan-
the same direction, the construction of a detached dike or break-
to prevent encroachments on the channel by shifting sand from
stward, and certain dredging.
nel Smith states that the forces of the currents in Sandusky
r are ample to excavate and maintain a wide and deep channel
y over the bar, provided they are properly directed, and the project
resented by him has for its object the widening and deepening of
annel by properly directing the current and by the arrest of sand
ent. This, in his opinion, can be accomplished by extending the
t jetty at Cedar Point as far as may be necessary to hold the out-
and eastward currents until their scour has made a channel at
0 feet deep entirely across the bar; by construction of a "sill"
am along the top of the bar from the light-house across the
on Track" to Sand Point, and supplemented there by three small
; by construction of a dike, approximately 5,550 feet long, par-
and 725 feet from the jetty; by protection of the slope of the
uth of the light-house with brush mattresses, and by the con-
ion of a dike 1,500 feet long at the outer end of the straight chan-
d a small spur on Cedar Point.

improvements contemplated are in the nature of extensions to
isting project now in course of execution. The cost of complet-
e existing project is estimated to be $185,000, and Colonel Smith
tes the cost of the extensions now proposed to be $240,796. Total
ted cost, $425,796.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers.
U. S. Army.

. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, February 28, 1898.

ERAL: I have the honor to submit the following report of a sur-
the bar at the mouth of Sandusky Bay, Ohio, and an estimate
cost of improvement, with a view to securing and maintaining a
nent navigable channel of sufficient depth next to Cedar Point,
uired in section 1 of the river and harbor act of June 3, 1896.
project, dated June 20, 1896, for expenditure of the amount appro-
d by the act above mentioned for improving the harbor of San-
, Ohio, included this statement: "The survey of the bar at the
of the harbor can be made in connection with examination of
els, and its cost will be covered in the amount estimated for con-
t expenses." This project was approved by the Secretary of War
, 1896.

As the fieldwork of the survey was to be carried on in connection with the prosecution of the improvements under the appropriation, no special surveying party was employed for the purpose, and the time for making such surveys as were specially required for completion of maps covering the entire outer bar and channel was taken whenever it would least interfere with other works in progress.

A hydrographic survey covering the entire bar across the mouth of the bay was made by Mr. William T. Blunt, United States assistant engineer, in October and November, 1896, the actual fieldwork covering a period of nineteen days. This survey was supplemented by further hydrographic examinations of the channel over the bar in May and in November, 1897.

The notes of the surveys were subsequently platted upon a large chart, scale 1–4000, and a report, with the map, was submitted to me by Mr. Blunt under date of January 25, 1898. A copy of Mr. Blunt's report is appended hereto.

The large map is unsuitable to accompany this report, and while better for studies of conditions, plans, and estimates, does not afford as comprehensive a view of the situation as smaller maps which will at a glance show some of the changes which have occurred upon the bar. I have therefore had two tracings made of charts compiled from the large map of Mr. Blunt's survey and others at earlier dates, and these tracings, marked sheet No. 1 and sheet No. 2, are forwarded in a separate roll to accompany and explain this report.

Sheet No. 1 is from maps of surveys made in 1826 and 1844.

Sheet No. 2 is from surveys made in 1872, 1896, and 1897.

The river and harbor act approved May 20, 1826, appropriated "four hundred dollars for making a survey of Sandusky Bay, to ascertain the expediency and expense of constructing piers, to improve the navigation thereof, and of placing buoys therein."

Under this requirement of Congress a survey was made by Lieut. Campbell Graham, of the Third Artillery, United States Army. Another hydrographic survey was made by Captain Canfield, of the Corps of Topographical Engineers, in June, 1844.

The results of these surveys are compiled on a chart, of which sheet No. 1 contains all the essential features. Some of the soundings taken in 1844 are platted in small circles on the tracing; the shore line of a breach through the long peninsula point is indicated in broken lines.

Soundings from these two surveys indicate considerable variation in the condition of the bar and channel, and to a small extent show that when the depths over the bar and point have increased the deep channel or "deep hole" near Cedar Point has been made smaller, yet the maps are not sufficiently complete or definite in locations of soundings to determine these points with any degree of accuracy.

In 1844 Peninsula Point had become an island, separated from the mainland by a channel about 1,500 feet wide, having a middle depth of 6½ feet. There were then three places where, in heavy gales, the seas broke over the top of the island itself. At that time the width between contours of 10 feet in the channel adjacent to Cedar Point was 650 feet. A map from a survey made in 1892, after the island had been entirely washed away, although the point had partially reformed on the western half, shows the section through which water could flow over the bar considerably larger than in 1844, and the width between contours of 10 feet depth in the same part of channel as before to be but 530 feet, thus indicating to a marked degree that the increased section for flow

over the bar had resulted in a decrease in the scouring effect of currents in the channel between the bar and Cedar Point.

The earlier maps are on a small scale and are necessarily lacking in matters of detail. A few points taken from later surveys will perhaps give a better illustration of the general principle that wherever there is a flow of water the amount of its effects at any one point will depend upon its concentration. If diffused over a large area it can not produce as great results at all points as would be reached at one place if concentrated there. It is, however, also true that the resultant effect in the sectional area of any one part of a channel will depend upon the directions as well as the velocities of the currents concentrated. At Cedar Point the converging currents are united in such a manner that the resultant maximum velocity is in mid-channel and the banks on either side are maintained with comparatively little reference to the central velocity which tends to produce depth rather than width. The results in both depth and width are again modified by the kind of material forming the bottom and banks.

While it has not seemed necessary to make borings in a depth of 40 feet, which is found in mid-channel at Cedar Point, the constancy of that depth and the nature of the material at a much smaller depth in the old inner channel, one of those radiating from that point, are enough to indicate a bottom sufficiently hard to withstand the action of all ordinary currents. The banks at that place are of sand, and are maintained with but little variation through the action of the currents and waves which carry the sand toward the top of the very steep slope. It has appeared, therefore, that a section of the channel at the outer end of the "Deep Hole," beyond the place where outflowing currents are united, where bottom and banks are sand, and near where a deeper channel is needed, would be the most suitable place for a comparison of channel conditions.

From 1862 to the present time the section over the bar west of the channel at Cedar Point has been undergoing constant changes, and a broad channel has been cut entirely through the bar at a place which has long been known as the "Wagon Track." The location of the top of the bar has moved considerably, so that exact comparisons of the sectional areas are difficult to make. The mean depth in 1896 was, however, greater than in 1872.

In a section near outer end of "Deep Hole" in 1862 the width between contours of 12 feet was 1,465 feet; in 1872 the width between same contours was 1.290 feet; in 1892 the width was 1,060 feet, and in 1896 it was 1,045 feet.

In the same section the widths between contours of 18 feet depth were, in 1862, 925 feet; in 1872, 760 feet; in 1892, 580 feet, and in 1896, 575 feet. These indicate a tendency to the deterioration of the channel over the outer bar, notwithstanding the fact that from 1867 to 1897 more than $90,000 was expended by the United States for its preservation by the removal of nearly 450,000 cubic yards of sand, besides more or less dredging from time to time by persons or corporations who were specially interested in maintaining the depths.

In 1873 the tonnage crossing the bar, amounting to but 541,123 tons, was in small vessels, mostly under sails. In 1893, twenty years later, the tonnage crossing the bar amounted to 1,524,183 tons, and was mostly in steam vessels, many of them large. Steam vessels crossing the bar in great numbers would disturb the bottom and thus effect a tendency to preserve and even increase the channel depths.

While the maintenance of deep channels inside of Sandusky Bay, from Cedar Point to the city front, will always be a source of some comparatively small expense, yet the improvement upon which all else must depend will of necessity be at the entrance over the bar between Cedar Point and the lake.

Formerly channels of small depth were sufficient, and most vessels could pass in and out at Sandusky without special difficulty. Most of the lake freights are now carried in large steamers, and the tendency is for all small freighting craft to disappear because the cost per ton for freight is less in large vessels.

It is evident that at harbors where large vessels can not easily or safely go at all times the shipping of freights will be at such a disadvantage that, save for purely local business, competition with more favored ports can not be maintained, because the force required to carry freight will, like other forces, ultimately find its way along the lines of least resistance.

The question is therefore presented how to secure and maintain a deep and reliable channel over the bars at the least expense.

The tributaries of Sandusky Bay consist of the Sandusky River and a few small creeks. The river, which is the only tributary of sufficient size to produce any appreciable effects, is a small stream having a very sluggish flow during most of the year, and its maximum outflow, even when augmented by the flow from the creeks, is entirely insufficient to account for the scouring effects observed.

The average wet section of the Sandusky River at mean level is hardly more than 2,600 square feet, and the total wet section of all the tributaries to the bay, at the same level, is probably less than 3,000 square feet. The wet section of the "Deep Hole" channel at Cedar Point exceeds 17,000 square feet, and over the top of the bar, on the same line, it exceeds 27,000 square feet. The wet sectional area through which water flows at the mouth of the bay is therefore approximately fifteen times as great as the total section of all the tributaries. We must therefore look for some other cause than the outflow from the drainage basin for the maintenance of that section.

While the mean level of Lake Erie is the resultant effect of various causes, the observed extremes of surface level have been the immediate and temporary results of winds in severe storms. The middle of Lake Erie east of Sandusky lies a little north of the entrance to the bay, and in a direction approximately east-northeast. The middle line of the lake west of Sandusky is in a direction nearly northwest, and the middle of the bay is on a line approximately east and west.

The effect of very strong winds from the northeast is to lower the surface in the east end of the lake and to raise it in the west end. At such times the lake surface at Monroe and in Maumee Bay is raised more than 5 feet. Very strong westerly winds drive the water along to such an extent that on several occasions within a few years the surface at Monroe has fallen 7 feet or more within a few hours. Unfortunately, no complete record of the water levels in Sandusky Bay has been kept, so that the extreme fluctuations at that place are not known. A glance at a chart of Lake Erie and Sandusky Bay will be sufficient to show that the same causes which result in such fluctuations at the west end of the lake must necessarily produce similar effects, though less in extent at and near Sandusky. This is known to be the case, although, as before stated, no complete record or systematic observations have been recorded.

These fluctuations of level cause the water to flow into and out of the bay with very rapid currents. The times when these currents are

est is when winds and waves are so high as to render it impracto make reliable observations on their velocity or direction. It known that during easterly winds the water flows from the lake e bay, and that the currents and waves tend to move the sand bar from the east and southeast, especially over the part near ore, and thus contract or fill the channel from that side.

ing the construction of the jetty from Cedar Point, in the season 7, the currents were occasionally found so strong, even when the vas light, as to cause considerable difficulty in handling scows with stone. Currents along the shore from the eastward passed l the end of the work as it progressed with sufficient force to way the sand and thus add to the depth in which the jetty had onstructed.

ms from the eastward are, however, less in number and violence hose from northerly and westerly directions. Waves and currents l by these winds drive the sand along the bar in such manner as roach upon the channel from that side.

en the currents entering the bay are sufficiently strong the sand has accumulated near Cedar Point is driven inward, and it is tly from this cause that the bar has been formed around the nd of the "Deep Hole."

outward currents are far stronger than the inward, not only e of the heavier winds and rapid lowering of the lake outside of r but because of the slightly added flow due to the drainage When these currents pass beyond the bar they spread but litny, to the northward and westward, because of the seas and curriving along the bar from those directions, so that the resultant t flows over that portion of the bar to the southward and east-These currents drive the accumulated sand along with them heir force has been dissipated by covering too large an area. tward extension of the bar on the northwest side of the "Deep channel and its continuation is probably not primarily due to the rough the "Deep Hole," but rather to the outward currents over of the bar itself.

e of these points were quite fully discussed in a report dated ber 1, 1894, printed in House Ex. Doc. No. 91, Fifty-third Conthird session; also in Report of Chief of Engineers 1895, pages 3089. It was upon this report that the latest project of improves based.

as to prevent the spreading of the current to the eastward and nsequent reduction in its force that the present project for ring Sandusky Harbor included the construction of a jetty on ntheast side of the channel from Cedar Point. The same project es a detached dike on the northwest side of the channel, prin- for the purpose of arresting the movement of the sand, but ntally to serve as a contraction work.

ing the season of 1897 the jetty from Cedar Point was extended oint 1,775 feet from shore, and the foundation of brush and stone xtended somewhat farther to check the scour around the end he eastward. The effects of this jetty are already very notice- deepening the channel to a considerable distance beyond its nd, but the time of its operation thus far is too short to afford rtainty of what it will ultimately accomplish.

ing the season of 1897 two light-houses were constructed on the ar to form a range on the axis of the channel over the outer bar, emplated in the project. The beacons have, however, been com- while progress upon the jetty and dike has necessarily been lim-

ited by the available funds. The lighting of the beacons will therefore necessarily be deferred until the channel is sufficiently far advanced to have its line of deepest water marked by the new range beacons. A more complete study of the situation than had been possible when the latest project was devised has led to the conclusion that the jetty and dike therein planned are well adapted to the purpose, but not sufficiently extended to insure a permanent and satisfactory channel.

The forces of the currents are ample to excavate and maintain a wide and deep channel entirely over the bar, provided they are properly directed. It is evident that in order to compel the currents to work along a particular line they must be kept from going elsewhere until they have reached a point where they may be trusted to complete their task after being set at liberty.

It is also evident that in so far as the movement of sand into the channel may be arrested, the securing and maintaining of a good channel will be the more rapid and certain.

The front beacon and keeper's dwelling of the range which marks the straight channel from Cedar Point to the city front is very nearly upon the extreme end of the bar which extends nearly across the mouth of the bay. The protection of the bar near this light-house is of itself important. Any further wearing away of the bar will not only reduce the amount to which the currents can be concentrated in the channel, but the material scoured away where depth is not wanted will tend to fill the places where depth is indispensable.

I have concluded that the desired object can be best attained by the following-named works of construction:

First. To extend the jetty from Cedar Point as far as may be found necessary to hold the outward and eastward currents until their scour has made a channel of 20 feet depth or more entirely across the outer bar.

Second. To prevent the further lowering of the crest of the bar by constructing what may be termed a "sill," consisting of brush mattresses cheaply made and loaded with sufficient large and small stone to secure them in place. Across the "Wagon Track," where the water is deeper, the "sill" would be raised to within 2 feet of mean water level. This sill and dam would follow the general line of top of bar from the light-house to Sand Point, as shown on sheet No. 2. It is supplemented by three small jetties constructed in the same manner to insure the stability of Sand Point.

Third. From the light-house the dike formerly proposed should be made continuous; its construction should be deferred until after the bar protection has been completed, and should then be extended outward in connection with the jetty on the other side of the channel, until it is found that the further extension is not needed to accomplish the result. How far it will be necessary to extend these works it is impossible to determine accurately in advance. I have therefore considered it wisest to make the plan and estimate cover the maximum which appears at all probable, in the hope and expectation that the results will be obtained without the necessity of completing the entire amount.

It is proposed to raise the top of the extended jetty on southeast side to the mean lake level only, and to mark its location by stone so piled at various places as to form sufficient day beacons.

On the northwest side it is not considered necessary to raise the top of dike higher than a plane 3 feet below mean lake level, except for 100 feet at the inner end near the light-house, where it should be raised to mean lake level.

Fourth. The steep slope of the bar extending into the channel south the light-house at the intersection of sill and dike should be protected by mattresses of brush held in place by stone.

Fifth. In order to prevent the inward and outward currents from storing the original condition of the inner bar, thus closing the outer d of the straight channel, which they have evinced a great disposition accomplish, a dike has been planned to so deflect these currents that ey shall tend to deepen rather than to obstruct the channel.

The exact sequence in which these works should be constructed is t necessarily outlined in this report, as it must be determined largely the amount of funds available at any one time and by such results may be accomplished while the work progresses.

The jetty and dike are parallel and are 725 feet apart. That distance ords ample room for entrance from the lake and channel room ween. It is quite probable that during the construction of these rks the scour which will be induced may result in extending the deep annel by pushing the sand outward and leaving it farther along and is reduce the depth until the extension of the contracted current ill be sufficient to connect the deep channel with deep water in the e. This temporary effect may necessitate dredging to prevent interstion of the channel. The quantity of material to be dredged can dly exceed the amount for which an estimate is included in the sent project.

The works of construction for which the estimate is most conveniently de cover all that are now considered necessary, and therefore include tain incomplete parts of the present project, viz, a length of 725 feet jetty on east side and 2,500 feet of dike on west side, the sections of ich are somewhat modified in the later plan with a view to reducing pense.

The cost of these items, amounting to $77,000, is therefore deducted m the total, to give the estimated cost of additions considered essary.

With these remarks the following estimate is submitted:

Extending east jetty 3,225 feet beyond present limits, to complete a length of 5,000 feet:	
Brush mattress, 19,000 square yards, at 40 cents	$7,600
Stone, including laying top and slopes, 54,500 tons, at $1.50	81,750
Beacons, two 6 feet square and 8 feet high; one 10 feet square and 12 feet high	420
Spur from Cedar Point—brush and stone	800
Total	90,570
For protecting crest of bar and shore of Sand Point, sill of brush mattress, 8,000 feet long, 16 feet wide, covered with stone 1 foot deep, and having a dump of stone along the middle 10 feet wide and not less than 2 feet high, and where water is deep not more than 2 feet below mean lake level:	
Brush, 14,300 square yards, at 40 cents	5,720
Stone, 14,000 tons, at $1.50	21,000
Three spurs on Sand Point:	
Brush, 2,700 square yards, at 40 cents	1,080
Stone, 2,064 tons, at $1.50	3,096
Total	30,896
Revetment of slope at front range light:	
Brush mattress, 6,250 square yards, at 40 cents	2,500
Stone, 4,840 tons, at $1.50	7,260
Total	9,760

West dike or jetty, 5,550 feet long, 10 feet wide on top, 900 feet in length raised to mean lake level; remainder to a plane 3 feet below mean lake level. Mattress to project 6 feet beyond foot of slopes, and that part to be covered with stone 1 foot deep:	
Brush mattress, 30,300 square yards, at 40 cents	$12,120
Stone, 80,000 tons, at $1.50	120,000
Beacons, four 6 feet square and 8 feet high; one 10 feet square and 12 feet high	500
Total	132,620
Deflecting dike for inner bar 1,500 feet long, 10 feet wide on top, and 2 feet below mean lake level, on brush mattress, extending beyond slopes and covered with stone, as in west dike:	
Brush, 10,000 square yards, at 40 cents	4,000
Stone, 33,300 tons, at $1.50	49,950
Total	53,950
Total for all works of construction	317,796
Included in approved project	77,000
Estimated cost of extensions proposed	240,796
Amount estimated to complete present project	185,000
Total	425,796

The estimates of quantities and cost of material to construct the works which I have devised have been made by Mr. F. S. Burrowes, United States assistant engineer. The quantities are doubtless as nearly correct as they can reasonably be made. I believe that the prices are sufficiently large to cover all contingencies of engineering.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. WM. T. BLUNT, ASSISTANT ENGINEER.

TOLEDO, OHIO, *January 25, 1898.*

SIR: I have the honor to file herewith a chart of the bar at the mouth of Sandusky Harbor, from a survey made in November, 1896, under your orders and in compliance with requirements of river and harbor act of June, 1896.

Work of survey was begun October 22 and finished November 21, actual field work occupying nineteen days of that period. The work was done by myself and the crew of the steamer *Swansea*, Captain Stevenson, and the boatmen being regularly at work, assisted when necessary by the engineer and fireman.

Survey was based on a secondary triangulation connecting with the primary triangulation of the Lake Survey, but owing to the absence of available points for connection the final calculations can not be made until a base can be measured. The azimuths were adjusted by working back to the ends of the primary base on Cedar Point, and are practically correct. While distances may be in error slightly, the discrepancy will hardly show on the scale used.

Geodetic positions were calculated and the chart developed on a projection to a scale of 1:4000.

Shore line, topography, and elevations were determined by transit and stadia.

About 10,000 soundings were taken with a rod upon ranges laid out by wire-line measurement, checking where possible, and located on these ranges by sextant angles. I believe all to be reasonably correct, and those not within the limits of the scale to be very few. Water surface during the survey was from 1.4 to 2.2 feet below mean level of Lake Erie, 1860–1875, but on the chart depths and elevations are given at mean level in feet and tenths. Contours are drawn for each foot of depth, intervals of 5 feet being shown in heavy lines.

The new stone jetty, of which about 2,000 feet was completed in 1897, is shown on the map.

, about 1870. From comparison with the published chart of that survey on
1:20000, it appears that Sand Point has extended nearly due south about
00 square feet, and that the water over the bar is quite perceptibly shoaler.
py of the original map of the Lake Survey on a large scale can be procured
nparison would be useful.
survey of 1892 made under your direction only covered the immediate vicin-
the channels which are influenced by dredging from year to year. Compari-
ow that the 18-foot curve around the "Deep Hole" has extended outward at
nd, while the general limits of the steep banks are practically unchanged.
egular observations of currents have been made, but probably personal obser-
s are fully as accurate and serviceable on account of the great and sudden
ions. Hardly a day passes without some current in or out of the entrance, even
absence of winds. The area of Sandusky Bay is so large and the bar to the
assage of water so decided, that the slightest variation of pressure on either
uses a translation of water. The current so induced varies from a gentle one
t weather to a strong flow in gales of winds. A wind from the lake north-
east throws a heavy current up along the shore and around Cedar Point
h the "Deep Hole," a large part thence passing in through the Straight Chan-
Large portions of water also pass in over the bar as the surface rises, and I
oted a current around the Straight Channel front beacon so strong as to test
ility of one man to pull a boat against it. I estimated this current one day
s been at least 3 miles an hour. A 3-mile current in the "Deep Hole" is quite
n.
the wind from northwest, west, or southwest the water flows outward,
rrents are usually not as strong and are more generally confined to the
l, the bar being more abrupt on the inside and tending to guide the water
s natural outlet. The area of the bay is so large as to make a reflex move-
fter these changes, and the consequence is a marked current one way or the
greater portion of the time.
nk that with the more serviceable steamer and the office help allowed me,
f which have been recently granted through your efforts, I shall be able to
ese matters the closer attention they demand. I shall endeavor not only to
comparative record of the changes in the channels and about the jetty, but
er the bar, and of the currents under varying conditions.
Very respectfully,

WM. T. BLUNT,
United States Assistant Engineer.

JARED A. SMITH,
Corps of Engineers, United States Army.

M M 17.

SURVEY OF BLACK RIVER (LORAIN) HARBOR, OHIO.

therein, made to comply with provisions of the river and harbor act of June 3, 1896.

Colonel Smith, in the accompanying report, submits alternative plans. Plan A is designed to afford an entrance 400 feet wide in water 27 feet deep at mean lake level, and is estimated to cost $590,500. Plan B is for a harbor entrance in a depth of 29 feet of water at mean lake level, and is estimated to cost $695,500. The local officer remarks that—

> The present indications of development in lake commerce are that the principal freights will be carried in much larger vessels than heretofore, and that harbors which can not afford them a safe entrance and sufficient depth of water will not only fail to increase in business but can hardly avoid suffering great loss in interests previously established.

Respecting the two plans presented in his report, he says:

> Between the two plans, "A" and "B," presented with this report, a glance will be sufficient to show the great superiority of plan "B" for every business purpose and for a harbor of refuge. In point of expense only the former plan is to be recommended.
>
> In my opinion it is not wise to limit the provisions for a harbor at such a place to present necessities only, and looking to the future the larger and more expensive plan is the one which will best serve the purposes required.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 1, 1897.

GENERAL: I have the honor to submit the following report of a survey of the harbor of Black River (Lorain), Ohio, and the estimated cost of improvement, "with a view to providing better access to said harbor and the safety of boats therein," as required by the river and harbor act of June 3, 1896, and by letter from office of Chief of Engineers, dated June 17, 1897:

To explain the present conditions and the necessities of navigation, a brief outline of the development of such harbors on Lake Erie will be pertinent.

The first project for improving the channel at the mouth of the Black River, Ohio, in order to permit its use as a harbor, was adopted in 1828, in compliance with a provision in an "act to authorize the improving of certain harbors," etc., approved May 23, 1828, as follows: "Towards removing the sand bar at or near the mouth of Black River, in the State of Ohio, by the erection of piers or other works, seven thousand five hundred dollars."

At that time the commerce of the lakes was comparatively small and freights were carried in small sail vessels. Depths of 8 to 10 feet of water at harbor entrances were ample and the piers required could therefore be of a very simple and inexpensive construction. When the piers were made of timber cribs they usually rested upon or but slightly below the natural bottom of the lake near the shore. When greater channel depths became necessary the piers were extended farther into the lake and the scour of the current was assisted by dredging. Meantime the old piers became more or less decayed, worn, and undermined

s or currents, so that they were necessarily repaired or rebuilt.
and driven along the shore under the action of the winds and
has had its movement arrested by the piers, resulting in an
ce of the shore line and the formation of a sand beach on one or
ides of the harbor entrance. The advance of the shore line has
ed in pushing the contours of depth farther into the lake until
of the sand has been driven past or between the ends of the piers,
ars, sometimes two parallel bars, have been formed across the
el. The sand of the broadened beach has been driven along by
nd, often fairly filling the air to a height of several feet, until it
d the channel between the piers, where it has fallen and caused
injury to the channel until removed by dredging or driven out to
r by the strong current of a freshet.

m the foregoing brief description it will be readily understood,
ly that the cost of maintenance has been a very great factor of
se, but that the channel depths, especially at the harbor entrances,
een subject to constant variations and uncertainty from a chang-
ttom in addition to those resulting from changing elevations of
ke surface.

obstruction of channel by drifting sand has been less at the har-
Lorain than at most other harbors similarly located in the mouths
ers on Lake Erie, but the piers have suffered as elsewhere from
and the effects of ice, drift, water, deepened channels, and other
s, so that the greater portion is now in bad condition.

extensions of piers constructed in 1889 and later are compara-
new, their total length being approximately 140 feet on the east
nd 238 feet on the west side. In 1893 a section of east pier 151
ng, which had fallen into the deepened channel, was rebuilt, and
the present season a section of west pier 396 feet long is being
t.

newest part of pier, built previously to 1889, was completed
y-two years ago, but the greater part is very much older, and all
s in such condition that it must soon be rebuilt for the preserva-
f the channel, because no mere repair can be judiciously under-
. When the old pier on east side is rebuilt, the alignment should
nged to give a better and wider channel. This will require the
reconstruction of east pier, save the part at outer end 140 feet
The total length which should be rebuilt within a few years is
feet on the east side and 365 feet on the west side. The estimated
therefore included in this report.

vast commercial interests of the lakes have been so much devel-
in recent years that an entirely different class of vessels is now
yed and those formerly used have practically disappeared. Under
rity of Congress the depth of channels between the Great Lakes
een gradually increased, and a minimum depth of 20 feet will soon
ained throughout. Every increase in navigable depths has been
ed by an increase in the size and draft of vessels, until many of
exceed 400 feet in length, and still greater ones are now under
uction, to carry from 6,000 to 7,000 tons of coal or ore.

t of the vessels carrying freight on the lakes are now propelled
red by steam power, and when fully loaded there are but few
draw as little as 16 feet of water. Most of them ordinarily draw
18 feet with a tendency to still greater depths. For such vessels
er a harbor during even an ordinary storm requires a depth of
at the harbor entrance very much greater than is needed in the
ratively protected channels between the lakes or the fully pro-

For the purpose of this report a hydrographic survey was
under my direction in September and October, 1896, and it ha
supplemented by maps from previous surveys, covering an area
1 mile long along the lake shore and extending into the lake to a
of 29 feet. Upon the map thus constructed is shown the outer p
of the present harbor of Lorain, the proposed alignment of eas
and plans for breakwaters to provide "better access to said harb
the safety of boats therein." The map is forwarded to accompa
report.

Two plans for breakwaters are indicated upon the map, n
respectively Plan A and Plan B. The plans are essentially alik
in dimensions, depth of water at the entrance, and protected are

Plan A is designed to afford an entrance 400 feet wide in water
deep at mean lake level, determined by records from 1860 to 1875.
will ordinarily afford a depth of 25 feet under unfavorable condit
the lake.

The breakwaters are given such directions and locations th
impact of heavy seas upon them must be from such directions t
drift will be carried from the entrance and the formation of a
any action of storms on the lakes will be effectually prevented.

It may be well to submit a brief explanation of this part of the s
The fact that unless the surface of water is exposed to the ac
winds over a considerable distance where the depth is great n
heavy seas can be produced is too well understood to require con
It is evident that all winds blowing from land, even though obli
will leave the lake surface near the shore comparatively smooth.
waves are raised, a forward motion is produced; the surface of t
slope of the wave is constantly falling, water beneath is displa
the direction of the wave motion, and the surface in front of the
is raised. In great depths the actual water in the wave itself h
very slight forward movement, but the displacement of the
beneath is such that a large volume is moved through a shorter di
than that traversed by the wave, and the total forward moven
water is sometimes nearly as great as though all the body of the
were transferred while the part below remained quiescent. Whe

bottom, and heavy seas can only arrive from the lake in directions making a considerable angle with the general line of the shore. The breakwaters are so placed that it is believed that no heavy seas will impinge upon them from such directions as to chase along the breakwaters toward the entrance, but, on the contrary, all such seas will be turned from the entrance, and the resulting wave motion, current, and scour, becoming greater with the distance traversed because of receiving constant additions, will drive the sand upon the beach at points too far from the entrance to be again returned. Seas which are driven directly in at the entrance between breakwaters after passing that point will necessarily be greatly reduced in height by spreading over the widened area within; the water between the piers will be comparatively smooth, and loaded vessels will be able to enter the channel where the depth is smaller than at the entrance without danger or difficulty.

Plan B is for a harbor entrance in a depth of 29 feet of water at mean-lake level and the two wings are each necessarily somewhat longer than in Plan A. From whatever point it be considered, Plan B affords the better and safer entrance because in deeper water, the greater protected area for use as a refuge, anchorage, or other purposes, and the sea has more room in which to lose its force before reaching the entrance to channel between piers.

The choice between the plans must then be decided by the necessities to be served and the expense involved in each.

Each plan involves the discontinuance of the present project for extending piers, except a length of 100 feet on east pier. The renewal of worn and decayed parts of old piers will be necessary in each case.

The estimated cost of the improvements in each case is as follows:

PLAN A.

East breakwater 1,200 feet long.	
West breakwater 1,500 feet long.	
2,700 feet, at $145	$391,500
Two pierheads, each 50 feet square, 100 feet, at $285	28,500
Extending east pier 100 feet.	
Rebuilding east pier 1,515 feet.	
Rebuilding west pier 365 feet.	
1,980 feet pier, at $75	148,500
Dredging area outside of piers in anchorage to depth of 20 feet, 62,500 yards, in scows, at 16 cents	10,000
Dredging channel 20 feet deep and widening same, 60,000 yards, in scows, at 20 cents	12,000
Total	590,500

PLAN B.

East breakwater 1,500 feet long.	
West breakwater 1,800 feet long.	
3,300 feet, at $150	$495,000
Two pierheads, each 50 feet square, 100 feet, at $300	30,000
Extending and rebuilding piers, and dredging same as in Plan A	170,500
Total	695,500

The freight tonnage of Lorain Harbor has been increasing during several years, and new facilities have recently been introduced which promise a very large increase in the near future. In 1896 the freight entering and leaving the harbor amounted to 565,219 tons.

During the season of 1897 the Cleveland Shipbuilding Company has been inaugurating works involving an expenditure of about $600,000

for constructing a complete shipbuilding plant at Lorain. Among other facilities, the dry dock, now nearly completed, is the largest upon the lakes; its dimensions are 500 feet long and 60 feet wide on the bottom, and 560 feet long with a width of 98 feet on top. This great shipbuilding industry will not only add to the freight tonnage by water, but will be the means of attracting many unloaded vessels to the harbor for repairs and for winter quarters.

The extensive steel manufacturing works which have been in operation but a comparatively short time under the name of "The Johnson Company," has in the season of 1897 doubled its freight tonnage of 1896, and is soon to erect furnaces of such capacity as to more than double the entire freight tonnage of the harbor. On these points a statement has been received from The Johnson Company, a copy of which is appended as part of this report.

The Cleveland, Lorain and Wheeling Railway Company, which connects the harbor with the extensive coal deposits of Ohio and Pennsylvania, has recently erected an additional plant, at an expense of about $100,000, for handling the anticipated increase in coal and ore shipments. During the summer of 1897 there has been a falling off in coal shipments, owing to unusual conditions of a prolonged strike among the miners of bituminous coal, preceded by a general business depression. These are, however, only incidents and do not materially affect the fact of a constant increase in receipts and shipments by water. To further explain this point, a copy of a letter from the general manager of the Cleveland, Lorain and Wheeling Railway Company is appended, to accompany this report.

The foregoing are given as the principal commercial interests of the harbor of Black River, or Lorain, as it should more properly be designated, but there are other minor business interests more or less dependent upon water freights, such as lumber, wood, fish, stone, and sand.

The present indications of development in lake commerce are that the principal freights will be carried in much larger vessels than heretofore, and that harbors which can not afford them a safe entrance and sufficient depth of water will not only fail to increase in business, but can hardly avoid suffering great loss in interests previously established.

Between the two plans, "A" and "B," presented with this report, a glance will be sufficient to show the great superiority of Plan "B" for every business purpose and for a harbor of refuge. In point of expense only is the former plan to be recommended.

In my opinion, it is not wise to limit the provisions for a harbor at such a place to present necessities only, and looking to the future the larger and more expensive plan is the one which will best serve the purposes required.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

LETTER OF THE JOHNSON COMPANY.

THE JOHNSON COMPANY, LORAIN, OHIO, AND JOHNSTOWN, PA.,
Lorain, Ohio, October 15, 1897.

DEAR SIR: We are pleased to hand you herewith information pertaining to our lake freight receipts and shipments for the years 1895, 1896, and 1897. We have

led in the tonnage for the latter year shipments which are under contract to go rd previous to the close of navigation. The figures given include only such ials as have been received or shipped from our own dock at Lorain. We have ious times been the consignees of large amounts of iron ore for transmission to or blast furnaces with which we have had conversion arrangements. As such ts at Lorain will be comprised in the statistics furnished by the Cleveland, n and Wheeling Railway Company, we have omitted them from the following nent:

Receipts and shipments at The Johnson Company's dock.

RECEIPTS.

Material.	1895.	1896.	1897.
one.....net tons..	12,500	.....	12,000
n.....gross tons..	10,500	10,300	.....
ng sand.....net tons..	8,500	900	.....

SHIPMENTS.

ails.....gross tons..	2,900	.....	8,000
lates, etc.....do....	360	.....	700
.....do....	.....	.....	.....

der normal business conditions the above figures would have been largely ased and a regular line of freight-carrying steamers stopping at Lorain would swelled the total tonnage by a considerable amount. All of our lake freight the present time has been carried by chartered schooners and propellers of not 1,000 tons capacity.

further explanation of the above it may be stated that the existing plans of The son Company at Lorain comprise a Bessemer steel works and rolling mills, turn- nt billets and steel rolls as finished product. The annual output of the plant ng full would be in the neighborhood of 360,000 tons, employment being fur- d to something over 1,200 men. Under these conditions pig iron is the raw rial with which we start, and coal, coke, and limestone the principal adjuncts sary for the manufacturing operations by which it is converted into finished uct.

iron and fuel must come from the interior, with the exception of such iron as t times be secured from Cleveland furnaces. Limestone is obtained from Kel- sland by water. Our finished products are usually destined for inland points, ugh with improved service over the Erie Canal we can avail ourselves of water portation for seaboard shipments.

as, however, always been a part of our plan to make our own pig iron at Lorain. necessary developments have been delayed by unfavorable business and finan- onditions, but within the next two years we shall complete the erection of two furnaces upon the Black River, having a combined capacity of 1,000 tons of pig per day. This will necessitate the receipt at our docks of approximately 700,000 of iron ore and 160,000 tons of limestone annually. It is desirable that this rial come in boats of the largest tonnage that can reach our docks, and steps be taken to provide for vessels of the greatest carrying capacity to be found g the lake fleets.

consider that the improvement of the harbor will enable us to take advantage portunities in the way of freights that are not now available, and a very mate- ncrease in our lake traffic can not fail to accompany added facilities in this tion.

trust that the information herein contained may be such as you desire and may in the formation of a decision to recommend for the harbor improvement at n that plan best calculated to satisfy the future requirements of what we con- ly believe is to be one of the most important ports on the southern shore of Erie.

Respectfully,

THE JOHNSON COMPANY,
Per F. A. SMYTHE.

t. Col. JARED A. SMITH,
United States Corps of Engineers.

LETTER OF THE CLEVELAND, LORAIN AND WHEELING RAILWAY COMPANY.

THE CLEVELAND, LORAIN AND WHEELING RAILROAD COMPANY,
Cleveland, Ohio, October 25, 1897.

MY DEAR SIR: In compliance with your recent request, I beg to submit figures showing the shipments and receipts of freight over our docks at Lorain Harbor:

	Season of 1895.	Season of 1896.	Season of 1897 to October 1.
Forwarded:	*Tons.*	*Tons.*	*Tons.*
Coal in cargoes	262,698	311,743	86,909
Coal for vessel fuel	18,554	19,580	8,652
Steel billets	.....	.....	4,000
Received:			
Iron ore	214,218	191,445	286,848
Lumber, laths, posts, and ties	12,984	11,262	8,908

In explanation of the decrease in coal shipments this season as compared with previous ones, it should be stated that owing to the general business depression almost no coal was shipped prior to June 1, and on July 4 the great bituminous coal strike commenced and lasted until September 20, thus absolutely suspending all shipments of coal by water. Had it not been for this circumstance the shipments for this season would have shown an increase over those of 1896.

There is every reason to believe that our vessel shipments from Lorain will continue to increase from year to year, as the facilities for caring for the larger vessels are improved.

During the last two years at least $200,000 have been spent in developing new coal mines on the line of this railroad, the output from which will, to a great extent, be shipped via Lorain Harbor, and traffic arrangements have been made which will result in large quantities of coal from the State of West Virginia being shipped to the Northwest by way of that harbor also.

This company has recently, in anticipation of largely increased ore receipts, erected, at an outlay of nearly $100,000, a plant for handling it, and we are now having plans prepared for other extensive improvements on our docks, because of the altogether reasonable expectations of increased lake shipments during the next year.

If more detailed information is desired, kindly so advise.

Yours, very truly,

W. R. WOODFORD, *General Manager.*

Col. JARED A. SMITH, *U. S. A.*

M M 18.

SURVEY OF THE BREAKWATER AT CLEVELAND HARBOR, OHIO.

[Printed in House Doc. No. 128, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 2, 1897.

SIR: I have the honor to submit the accompanying report of November 15, 1897, with map; by Col. Jared A. Smith, Corps of Engineers, upon survey of the breakwater at Cleveland Harbor, Ohio, as heretofore planned, with a view of determining the advisability of changing the plan thereof so as to abandon the proposed construction of the eastern shore arm, and in lieu thereof extending the breakwater eastwardly in a general direction parallel with the shore, made to comply with requirements of the river and harbor act of June 3, 1896.

Colonel Smith's conclusions may be summarized as follows:

First. Such a modification would greatly increase the exposure of wharves and anchorage to the northerly and northeasterly storms.

econd. The expense of the same length of breakwater would be siderably increased because of the greater depth.
'hird. In case of a further extension eastward on the same line the bor would still have increased exposure to the north and northeast l a greater cost than if built nearer shore.
'ourth. The width between breakwater and end of wharves would too great.
'ifth. The cost of protecting the harbor from northeast storms by a re arm, which would ultimately be required, would be greater than he breakwater were built nearer shore.
ixth. An extension eastward from the end, as heretofore planned, ıld afford much better protection to wharves and anchorage at all es, would cost less, would afford ample room between wharves and akwater, and would be nearly 900 feet nearer shore, with a corre-nding decrease in the cost of a shore arm to protect the harbor from theasterly storms.
'hese points are deemed by Colonel Smith to be sufficient to indicate t it is not advisable, either with reference to present necessities or ıre requirements, to abandon the construction of the shore arm of breakwater as now planned.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Ion. R. A. ALGER,
Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, November 15, 1897.

ENERAL: I have the honor to submit the following report of a sur- of the breakwater at Cleveland Harbor, Ohio, as required by a ıse of section 1 of the river and harbor act of June 3, 1896, as OWS:

ıd provided also, That the Secretary of War be directed to cause a survey to be le of the said breakwater as heretofore planned, with a view of determining the isability of changing the plan thereof so as to abandon the proposed construc- of the eastern shore arm, and in lieu thereof extending the said breakwater ıwardly in a general direction parallel with the shore.

'he application of the term "breakwater" as used in the foregoing uirement of law is not understood to be limited to the structure lf, but is assumed to include whatever area may be necessary for a ıplete understanding of the situation. The entire outer harbor of veland is often popularly called "the breakwater," and apparently s in a kindred sense that the name was applied in the clause above ıted.

n September, 1896, a very complete survey was made under my ection by Mr. William T. Blunt, assistant engineer, employing the all steamer *Swansea*, boats, and crew in making soundings and ıminations of the bottom. A copy of that part of Mr. Blunt's report ich describes the survey is appended hereto. A tracing of the map, h some recent additions, is forwarded to accompany this report.
'he hydrographic portion of the map covers an area 2½ miles long l 4,000 to 6,000 feet wide. Its eastern limit is 1¾ miles east of east-

ern end of breakwater as heretofore planned, and the line of shore extends somewhat farther.

The plan of the east breakwater is shown upon the map. The main front on the lake is on the same line as that of west breakwater, a space of 500 feet being left for an entrance to the harbor opposite the mouth of the river. It extends a length of 3,500 feet on the lake front, and then changing direction 26° toward shore, a farther distance of 2,000 feet. The last-named part is that which has been designated as the "shore arm."

A length of 2,494.5 feet on the lake front of the east breakwater was completed in 1893, since which time no additions have been made. The length now remaining to be built to complete the breakwater is therefore 3,005.5 feet.

In order to better discuss the question presented, it is assumed that if the plan of breakwater is to be extended eastward without change of direction, the total length will at first not be increased by the change, because of the limitations in cost which are made in the same paragraph relating to Cleveland Harbor in the act of June 3, 1896; the proposed change is therefore indicated upon the map, making the total length same as before.

Through the eastern end of the breakwater as heretofore planned, and its eastern terminus if given the same length without change of direction, heavy broken lines have been drawn, first on the meridians, and second at an angle of 45° thereto, indicating directions due northeast and southwest. The meridian through the end of breakwater as planned is about 350 feet east of the one through the point where it would terminate if built on a straight line. To afford the same theoretical cover from a north wind the straight-line breakwater would require a length approximately 450 feet longer than the one with shore arm.

The lines indicating the respective limits of areas sheltered from northeast storms show very plainly that the straight-line plan leaves nearly all of the anchorage on east side entirely exposed, and does not even fully cover the west side anchorage. The shore-arm plan, while still leaving a slight exposure to the northeast, affords vastly better protection than the other to both anchorage and wharves. The straight-line plan would have to be extended an additional distance of more than 6,000 feet eastward to afford the same direct cover from northeast winds that is furnished by the shore arm.

The average depth of water along the 2,000 feet of shore arm is about 3 feet less than over the corresponding length on the straight-line plan, and the cost for same length, if the proposed change be made, would therefore be increased.

An examination of the map in connection with the lines drawn to illustrate this discussion shows conclusively that a breakwater upon the present plan will afford vastly better protection from north and northeasterly winds than it will be possible to obtain at the same cost if the plan be changed as proposed without a considerable increase in length.

The requirement of law for a report upon the advisability of modifying the plan of the breakwater implies that the necessities of commerce may require its further extension eastward, and that such extension, if made, shall be on the prolongation of the line of its lake front.

In order to ascertain as far as possible the facts bearing upon this view of the subject, a letter was addressed to the Cleveland Chamber of Commerce briefly explaining the situation and asking for information upon a few definite points, to which a very complete reply has been received.

The correspondence is as follows:

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, September 30, 1897.

DEAR SIR: The act of Congress known as the river and harbor act of June 3, 1896, contained a clause regarding Cleveland Harbor in the following words:

"That the Secretary of War be directed to cause a survey to be made of the said breakwater as heretofore planned, with a view of determining the advisability of changing the plan thereof so as to abandon the proposed construction of the eastern shore arm, and in lieu thereof extending the said breakwater eastwardly in a general direction parallel with the shore."

In a separate roll I hand you a blue-print map of Cleveland Harbor, which will illustrate the present extent of the breakwater and the question raised in regard to its future extension.

The east breakwater now has a length of 2,494½ feet. The present plan of this breakwater contemplates a length of 3,500 feet, measured on a straight line from the east side of harbor entrance and thence a distance of 2,000 feet obliquely toward the shore to a point approximately on the prolongation of the west side of Muirson street, and about 2,250 feet outside of the shore line.

I am now required to submit to the Chief of Engineers a report upon the advisability of modifying the plan of the harbor in such manner that the entire eastern breakwater shall be on one continuous straight line. This is not directly a question of engineering so much as of expense and of public policy in the interest of the varied commerce and industries of Cleveland, of which the chamber of commerce is the representative body. The question is therefore submitted in the hope of receiving in reply some information which will assist in formulating a complete and conclusive report. I beg leave, however, to make the following suggestions:

First. From 1876 to 1883 the United States constructed a breakwater on the west side having a total length of more than 7,000 feet and protecting an area on the west side of which the shore line is slightly more than 1 mile in length. The west breakwater has been completed nearly fourteen years, during which time the United States has expended a considerable sum annually for maintenance, and it is now under the necessity of expending about $425,000 in order to renew parts which are decayed or worn. Meantime the depths in the protected area have been greatly reduced by various causes.

Up to the present time no wharf or pier for business purposes has been constructed within the area thus protected, which has been year by year losing its depth of water.

Second. The length of shore line and the area to be protected on the east side, according to present plans, are each nearly as great as the corresponding parts on the west side, although only the part west of Seneca street is now available for commercial business because of the frontage owned by the city for park purposes and by the United States for the Marine Hospital. Next east of Muirson street comes the new Lakeside Hospital.

If the breakwater were to be limited to the length now authorized, there would be no hesitation in deciding that the plan heretofore adopted affords far better protection than could be obtained by the same length in one straight line. The question now raised, therefore, seems to imply that the commercial interests of Cleveland are such as to justify the United States in extending the breakwater farther eastward than is now planned, and that such extension should be on a continuous straight line.

Any business which would require a protection beyond what is contemplated in present plans must necessarily be located east of Canfield street, and the farther the protection is from the shore the greater the length required to afford shelter from northeast storms. The original cost of the breakwater may be estimated at $160 per linear foot, and in twenty years the cost of maintenance will increase that amount about 50 per cent.

It seems pertinent therefore to ask:

First. What commercial enterprises are now in operation on the lake front of Cleveland east of Canfield street whose business would be greatly facilitated or increased by the extension of the breakwater sufficiently far to protect their respective water fronts?

Second. To what extent is it certain that a further extension of the breakwater eastward would develop new enterprises?

Third. If all the benefits to be derived from an extension of the breakwater beyond the limits of present plans were to accrue directly to the United States, would they be sufficient to justify the expenditure as a financial investment and enterprise?

Fourth. In consideration of the fact that the breakwater already covers a large area and shore line on the west side, of which no advantage has thus far been taken to develop commercial enterprises on the lake front and of the fact that an additional expenditure of $1,354,000 has been authorized by Congress, is it justifiable at present to submit a recommendation for the modification now proposed with all its direct and implied results?

Fifth. Should the commerce of Cleveland at present or at some future time be found to justify the expense of additional harbor room east of the limits heretofore adopted, would it not be better to construct an independent breakwater, covering only the space required, rather than to extend the present breakwater on the same line, resulting in a harbor which would leave room to develop a considerable sea from the northeast within its own limits?

Thanking you in advance for any consideration and reply which may be given to the questions here presented, I am,

Very respectfully, yours,

JARED A. SMITH,
Colonel, Corps of Engineers.

Mr. W. R. WARNER,
President of the Cleveland Chamber of Commerce, Cleveland, Ohio.

THE CLEVELAND CHAMBER OF COMMERCE, *October 20, 1897.*

SIR: I have to transmit herewith a copy of the report submitted to the Chamber of Commerce, at its general meeting held last evening, by the committee on harbor and docks and the executive committee of the Maritime Board, to whom your letter of September 30, addressed to President Warner, on the subject of the extension of the breakwater eastward, was referred. As indicated in the report, the chamber will be very glad to supplement any general statements embraced in the report by more definite and specific information if you will kindly indicate what would be desirable.

At the same time I desire to advise you that a resolution of thanks was unanimously adopted by the chamber, expressive of its sincere appreciation of the courtesy and consideration shown to the chamber by you in inviting its official interest upon this important matter.

Again thanking you, I am, very respectfully,

RYERSON RITCHIE, *Secretary.*

Col. JARED A. SMITH, U. S. A.

OCTOBER 16, 1897

Your committee on harbor and docks and the executive committee of the Maritime Board have met and considered the letter referred to them by your board of directors from Col. Jared A. Smith, United States Engineer in charge of the harbor improvements at Cleveland, and the matters therein brought forward. After full consideration of the subject it is recommended that a reply be addressed to Colonel Smith, the substance of which shall be to recommend and urge, on behalf of the commercial interests of the city of Cleveland, represented by this chamber, the extension of the breakwater easterly, preferably upon the line of the present breakwater extended. The reasons for this are, briefly, as follows:

The breakwater at Cleveland was begun under a plan submitted in 1875, the modification of which, under which the east breakwater is now projected, was made in 1888, the design then being to limit the breakwater by a shore arm at a point about opposite the foot of Muirson street. The enlargement of the original plan was made in 1888 upon a showing of the remarkable increase in the business of the district, in the commerce of the lakes generally, and in the size of vessels which were the instruments of this traffic. It was shown that in 1888 there were ships being built of the then great length of 310 feet, with a carrying capacity of 2,800 tons. Since that time, or during the past ten years, the increase in all these respects has been beyond the greatest expectations of anyone connected with the lake commerce at that time.

For the year ending June 30, 1897, more steam tonnage was built on the lakes than in all other ports of the United States combined. There are to-day many more vessels of a tonnage of 1,000 tons and upward on the lakes than in the entire American merchant marine, exclusive of the Great Lakes. There are many ships over 400 feet in length. Steamers are now building of 450 feet keel, and one is about to be built of 500 feet, and it is undoubtedly true that the demands and economies of lake commerce will necessitate the continued construction of vessels of great dimensions. A contract was recently let for a steamer guaranteed to carry 6,500 tons and for 2 consorts guaranteed to carry 7,000 tons each. Harbors, shipping facilities, and breakwaters which were entirely adequate ten years ago are now insufficient. So far as the purposes of a harbor of refuge are concerned, the breakwater, if completed as now projected, will be entirely inadequate to the demands of the commerce carried on in vessels more than double the size of those in use ten years ago.

The enlargement and deepening of channels by the Government has so greatly increased the facility with which cargoes are carried in large vessels, that the average rate for carrying a ton per mile on the lakes in 1897 will scarcely exceed one-tenth of the cost on the most favored railroad in the United States. Recent developments in business have increased the ore and other shipments by lake, so that in 1896 it is confidently predicted there will be an increase of 50 per cent over any previous year in the transportation of iron ore alone, and the same conditions will make

crease a continuous one from year to year. The fixed and established work of eakwater, together with the fact that the western arm extends absolutely to ore, makes it impossible to increase the accommodation behind the breakwater by extending it easterly.

enormous growth in lake traffic has already taxed the inner harbor of Cleve- almost to its capacity, and the lake business of Cleveland demands to-day sed facilities not merely in the matter of transshipment, but in the accommo- of business actually established in the city depending upon the receiving and ent of commodities by water, and there is no place available for the accommo- of local business of this character except east of the river.

ing the past five years there have been turned away from the city of Cleveland l very important enterprises, the shipments and receipts of which by lake be measured by hundreds of thousands of tons annually, solely for the reason o place for the accommodation of their business could be found except upon e shore east of the river, and that land was unavailable by reason of the lack tection by breakwater. And at least one institution already located there, the ts and shipments of which would aggregate almost 2,000,000 tons in a single of navigation, has been prevented from enlarging its facilities, and is said to nder contemplation the removal of its business, because its property is unpro- and ships could not come to docks which that company desires to construct.

cerning the statement that there is already a protected space west of the river has thus far not been utilized, the investigation made by your committee leads o report that this territory is available only for transfer docks—that is to say, receipt and transshipment of heavy freights, such as iron ore and coal. Rail- ompanies and others having appliances for that business in the inner harbor, is already overtaxed, have been ready for some years to make the necessary vements outside, and have only been deterred from doing so because of certain table controversies in regard to riparian ownership; and, in consequence of the to develop these possibilities, Cleveland as a transferring port has suffered ulable injury. But this business, at Cleveland's loss, has been accommodated ere.

h respect to the extension of the east breakwater, the condition is essentially nt. Protection is needed on that side, not for transferring docks, but for docks ich may be received and shipped commodities which enter into the local busi- f the port which could not, under any circumstances, be accommodated behind st breakwater and which can only be accommodated at other points at great ot only at Cleveland, but to the business interests of the country at large. It ascertained and established fact that Cleveland is the assembling point for ials in certain lines of manufacture which are dependent upon cheap water ortation for their existence. The available territory has been occupied, and tension of these lines of business depends upon furnishing protection to our ont as a receiving and shipping point west of the river.

le this is a matter of extreme importance to Cleveland as a city, your commit- not base their recommendation upon any advantage to local property owners, n upon advantage to the city; but we desire to report that, as a lake receiving ipping port, Cleveland has reached a point at which enlargement is absolutely ed for the accommodation of existing business, which can only be obtained extension of the east breakwater. There is no question that the business to e there, which to-day would exceed half a million tons, would, within a very ime, be increased tenfold. In this connection your committee desires to sub- an early date a supplementary report, showing the magnitude of the interests d and the prospective increase in water traffic in the event of suitable protec- ing furnished.

he chief center of the shipbuilding and shipowning interests of the Great Lakes, chief center of the iron and steel industry and lake coal trade, the fact is he small inner harbor of Cleveland has been outgrown, notwithstanding the liture during the last year of half a million dollars by the city in the improve- of the river. Great interests not located in Cleveland, but the business of mnst center here or suffer great loss, depend upon adequate facilities at this r the transaction of the commerce naturally gravitating to this city, and your ttee can see no possible means of accommodating this traffic, except by extend- breakwater easterly, not as a local improvement, but for the accommodation merce in which many cities and millions of our people have a direct and ant interest.

committees distinctly recommend against an independent breakwater and the extension of the east breakwater substantially parallel with the shore. ly the manner in which this should be done is an engineering question, but ld not be done, in the judgment of your committees, in any such manner as imit the breakwater by any means to its now projected dimensions or prevent ension as a continuous whole a considerable distance farther east than is now ed for.

planned is not, however, at present required. The discussion in this report is therefore restricted to the necessity for modifying present plans with reference to probable requirements of the future.

Examining the present plan of east breakwater and the proposed modification, with reference to the respective advantages offered for future development of the harbor eastward should it be required, we find:

That a face of the lake front of breakwaters when prolonged eastward is in general as much as 3,750 feet outside of the shore line, which is about 1,000 feet farther into the lake than the average distance of west breakwater from shore. The harbor line heretofore established, affording room for an anchorage outside of the wharves, is 1,700 feet inside of the inner face of the breakwaters, and that distance is ample for every reasonable demand of the future. Very few vessels anchor in the harbor, and generally those few are small pleasure craft, with an occasional large vessel which lies at anchor because out of employment.

The distance between harbor line and breakwater is about four times the length of the largest vessels at present plying on the lakes. It therefore affords ample room for turning or otherwise handling vessels with reasonable care.

If we assume that the breakwater is to be prolonged eastward in a direct line and that the harbor line to be established shall be at the same distance from breakwater as before, its extension eastward would be in water from 26½ to 31 feet deep, and an average depth of more than 29 feet.

It is not at all probable that any necessity for depths greater than 20 feet on wharf fronts will arise for many years to come, and should such a necessity arrive the greater depth could be more cheaply obtained by dredging than by extending the wharves farther into the lake. The contour of 20 feet depth in the lake east of the harbor limit heretofore planned is at an average distance less than 1,000 feet from shore. This would leave a space more than half a mile wide between the outer ends of wharves and the rectilinear breakwater, a width which is not only unnecessary but injurious, because of the room it affords within the harbor itself to raise a sea sufficient to prevent vessels from lying quietly at wharves during heavy northeasterly storms.

The line of lake front of the breakwater prolonged eastward, being farther from shore than the part now completed, is also in water of a greater depth, so that the cost of construction on that line would be considerably increased.

From the eastern terminus of the breakwater heretofore planned let a line be drawn eastward and parallel to the prolongation of lake front of breakwaters; it will be at an average distance of nearly 2,700 feet from shore and in water generally 33 feet deep. If we assume that the breakwater may be extended eastward upon that line after the structure heretofore planned has been completed, and that the extended harbor line be located 1,700 feet inside of the breakwater, as before, the limit thus established for wharves will be at a distance of nearly 1,200 feet from shore and in water having an average depth of about 22 feet. These conditions of depth and breadth are more than enough to satisfy every necessity of the immediate future, and to provide for all probable necessities of any period more remote.

The points with reference to the advisability of modifying the plan of breakwater in such manner as to extend it eastward on a straight line may be briefly summarized:

First. Such a modification would greatly increase the exposure of wharves and anchorage to northerly and northeasterly storms.

Second. The expense for the same length of breakwater would be considerably increased because of the greater depths.

Third. In case of a further extension eastward on the same line, the harbor would still have increased exposure to the north and northeast, and at a greater cost than if built nearer shore.

Fourth. The width between breakwater and ends of wharves would be too great.

Fifth. The cost of protecting the harbor from northeast storms by a shore arm, which would ultimately be required, would be greater than if the breakwater were built nearer shore.

Sixth. An extension eastward from the end as heretofore planned would afford much better protection to wharves and anchorage at all times, would cost less, would afford ample room between wharves and breakwater, and would be nearly 900 feet nearer shore, with a corresponding decrease in the cost of a shore arm to protect the harbor from northeasterly storms.

Other points to the same effect might be mentioned, but the foregoing are sufficient to indicate that it is not advisable, either with reference to present necessities or future requirements, to abandon the construction of the shore arm of breakwater as heretofore planned, and in lieu thereof to extend the breakwater eastwardly in a general direction parallel with the shore.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. WILLIAM T. BLUNT, ASSISTANT ENGINEER.

TOLEDO, OHIO, *January 13, 1897.*

SIR: I have the honor to transmit in separate roll a manuscript chart, scale $\frac{1}{1000}$, of a survey at Cleveland Harbor made in September, 1896, in compliance with your orders issued under the provisions of the river and harbor act of June 3, 1896.

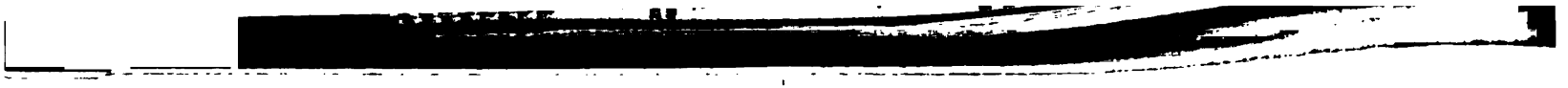
* * * * * * *

SURVEY AND CHART.

Triangulation.—Several of the old points of 1884 and 1892 were found and utilized. A new base was measured on west breakwater and reduced to standard length. East of Erie street the two points △ Otis and △ Intake were determined by use of a buoy anchored in the lake and carefully observed on but not itself occupied. These points are, therefore, located only sufficiently for use in general work. The true meridian was obtained by observation on polaris at east breakwater and is probably less than 10″ in error. A check on this was obtained at the true meridian monuments set in Marine Hospital grounds by the United States Coast and Geodetic Survey.

Shore location.—A survey by transit and stadia was carried along the shore locating prominent objects, bluff lines and heights, sounding ranges, etc., and checking on triangulation points. This was carried 3 miles east of the piers.

Soundings.—The soundings covered the area extending from the new Pennsylvania Company docks to 1,600 feet east of Case avenue, a total distance of 13,200 feet, and outward 4,000 to 6,000 feet from shore. They were taken on nearly parallel ranges normal to the general shore line, 200 feet apart until the old dumping ground at Erie street and the present projected location of breakwater were covered, then 400 feet apart until the present dumping ground off Case avenue was covered. These range lines were marked by flags and carefully located by transit. Soundings were taken from either a small boat or the steamer running along these ranges, and were located on the ranges by sextant angles, the outer ends of lines being tested by two or three sextant angles. A rod was used in water less than 22 feet deep, reading to tenths of a foot, and a tested lead line in greater depths, reading to one-half foot. About



5,000 soundings were taken on upward of 42 miles of ranges, thus averaging about 45 feet apart, but in shoal water being about 25 feet apart.

Borings.—Thirty-two borings were made at intervals along the line of projected breakwater, and on the prolongation of that already built, as far east as Case avenue. They were made with a small steel rod, forced by hand into the bottom. While it is usually easy to determine the change from mud to sand, to gravel, and to clay, the determination was nearly always verified by material adhering to the rod. Generally the rod was forced 2 to 3 feet into the clay.

Time.—Work was much delayed during shore winds or calms by heavy smoke from the city, and also by several heavy winds from the lake. Time consumed was from September 11 to 26; without the steamer and its trained crew the work would have consumed at least twice the time.

Chart.—Triangulation and transit points were reduced by latitude and departure to a plane rectangular projection and so platted, filling in being by polar coordinates and intersections. Depths and elevations were reduced to mean level of Lake Erie, 1860–1875. Contours of depth are drawn at each foot. True meridian is found to be 1° 38′ 15″ east of the magnetic meridian assumed in 1890 and used on charts made since that time. The entire work is platted on one sheet to a scale of $\frac{1}{2000}$. It connects with and overlaps that done in June, 1896, about the mouth of the harbor, which was platted on a scale $\frac{1}{1000}$.

* * * * * * *

Very respectfully,

WM. T. BLUNT,
U. S. Assistant Engineer.

Lieut. Col. JARED A. SMITH,
Corps of Engineers, U. S. A

M M 19.

ESTABLISHMENT OF HARBOR LINES AT SANDUSKY HARBOR, OHIO.

SANDUSKY, MANSFIELD AND NEWARK RAILROAD COMPANY,
Sandusky, Ohio, January 17, 1898.

The president and receivers of the Sandusky, Mansfield and Newark Road hereby make application for the establishment of a harbor line at Sandusky, it being the desire of this company to extend their docks.

They respectfully petition that the harbor line be located as shown on the inclosed plans.* This proposes moving the channel at that point 100 feet farther into the bay, and if the petition is granted the president and receivers obligate themselves to do the necessary dredging to the satisfaction of the engineers of your Department before obstructing in any way the channel as now located.

Respectfully,

JAY O. MOSS, *Receiver.*

The SECRETARY OF WAR.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
January 21, 1898.

Respectfully referred to Col. Jared A. Smith, Corps of Engineers, for report.

If, in Colonel Smith's opinion, harbor lines should be established at this locality, he will please submit a tracing showing the lines recommended for adoption.

To be returned.

By command of Brig. Gen. Wilson:

A. MACKENZIE,
Lieut. Col., Corps of Engineers.

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*Not printed.

[Third indorsement.]

U. S. ENGINEER OFFICE,
Cleveland, Ohio, January 25, 1898.

Respectfully returned to the Chief of Engineers with a separate letter and tracing.*

JARED A. SMITH,
Colonel, Corps of Engineers.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
February 1, 1898.

Respectfully returned to the Secretary of War.

The Sandusky, Mansfield and Newark Railroad Company, by Jay O. Moss, receiver, requests that harbor lines be established at Sandusky Harbor, Ohio.

Col. Jared A. Smith, Corps of Engineers, who has charge of the improvement of this locality, has investigated the subject, and attention is invited to his report of the 25th ultimo, herewith.

I recommend that the line proposed by Colonel Smith, shown by the broken black line on the accompanying tracing, be established as a pierhead line and that that portion of the line at intersection of the dock channel and straight channel be adopted conditionally upon completion by the railroad company of the dredging opposite its docks necessary to widen the channel as shown on the map, and that no modification or extension of wharves at that place be permitted until such dredging shall have been completed.

The tracing has been prepared for the signature of the Secretary of War.

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

[Fifth indorsement.]

WAR DEPARTMENT,
February 14, 1898.

Approved as recommended by the Chief of Engineers.

G. D. MEIKLEJOHN,
Acting Secretary of War.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cleveland, Ohio, January 25, 1898.

GENERAL: Referring to second and third indorsements on letter of J. O. Moss, dated Sandusky, Ohio, January 17, 1898, I have the honor to submit the following statement and recommendation regarding the establishment of a harbor line at Sandusky, Ohio:

It has for several years been apparent that the establishment of a harbor line along the principal wharf front of Sandusky Harbor is desirable, because it would permit of various modifications or exten-

* Not printed.

sions of most of the wharves without the necessity of obtaining authority from the Secretary of War in each particular case.

This application is on the part of the Sandusky, Mansfield and Newark Railroad Company, and has been made for the special purpose of enabling the company to increase its shipping facilities by the extension northward of one or more of its wharves.

I was consulted upon the subject some weeks ago and informed the officers of the company that authority from the Secretary of War would be required, and indicated my opinion that such authority would not be granted save on such conditions as should prevent injury to the channel or to the rights of other riparian owners.

To prevent injury to the channel and to riparian rights west of the railway company's wharves, the company proposes in advance of the extension to its wharf to widen the channel somewhat more than the additional length to which the wharf will be extended, as shown upon the blue print, and the consent* of all riparian owners who might otherwise be affected by a change in the lines of channel at that angle has been obtained and presented in triplicate, * * * accompanied by a statement* of lots also in triplicate. * * *

In a separate roll I forward a tracing of the principal part of the wharf front of the city, showing the channel which is partially dredged and the line recommended for adoption as a harbor line.

I recommend that the harbor line at intersection of dock channel and straight channel be adopted conditionally upon the completion of dredging by the railroad company to widen the channel as shown upon the tracing; that no modification or extension of wharves at that place be permitted until the dredging shall have been completed. In order that this office may know when the dredging is properly completed, it should be done under supervision of an inspector employed by this office but paid by the company, the inspector rendering all reports in the same manner as though the work were done by and for the United States.

Very respectfully, your obedient servant,

JARED A. SMITH,
Colonel, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

* Not printed.

APPENDIX N N.

IMPROVEMENT OF ERIE HARBOR, PENNSYLVANIA, AND OF CERTAIN RIVERS AND HARBORS IN WESTERN NEW YORK.

REPORT OF MAJ. T. W. SYMONS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

Erie Harbor, Pennsylvania.
Harbor at Dunkirk, N. Y.
Buffalo Harbor, New York.
Tonawanda Harbor and Niagara River, New York.
5. Niagara River from Tonawanda to Port Day, N. Y.
6. Wilson Harbor, New York.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., July 12, 1898.

GENERAL: I have the honor to forward herewith annual reports and summaries * * * on the following works in my charge:

* * * * * * *

Very respectfully, your obedient servant,

T. W. SYMONS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

N N 1.

IMPROVEMENT OF ERIE HARBOR, PENNSYLVANIA.

Original condition.—In its original condition the harbor of Erie was landlocked, the only entrance being to the east. The channel leading in and out was narrow and tortuous, variable in position, and with a depth of only about 6 feet.

Project for improvement.—The project for the improvement of the harbor as originally prepared in 1823 and approved in 1824 (at which time the entrance to the bay was narrow and tortuous and only 6 feet in depth) provided for closing all of the eastern end of the harbor by means of a breakwater in which should be left an opening 200 feet wide, and for extending to deep water in the lake two parallel piers, one on each side of the opening. This project is substantially in force at the

present time, excepting that the piers are 360 feet apart. It is understood that the project includes the necessary work of dredging to keep the channel open to the required width and depth, to make the required repairs to existing structures, and to do such work as may be found necessary from time to time for the preservation and care of Presque Isle Peninsula. This peninsula is the outer inclosure of the harbor of Erie, which is a landlocked bay about 5 miles long, having a maximum width of 1½ miles. The peninsula is a low sand formation about 6 miles long, varying in width from 300 feet at the "neck" to 1½ miles at its widest part. The "neck" is about 2 miles long and joins the body of the peninsula to the mainland at its western end.

The preservation of the peninsula is of vital importance to Erie Harbor, and it is for the purpose of preserving the harbor that the protection of the weak parts of the peninsula have been deemed necessary. The weak portion is the long narrow neck at the western end. The object for which all the works of protection have been constructed is the prevention of a breach through this narrow neck. The danger exists during severe storms from the westward.

At the present time there are no protection works except a few dilapidated pile jetties no longer of service, and the main line of piles, mattresses, and stone ballast on mattresses of the shore protection constructed in 1889.

During the past year there has been considerable erosion along the neck of the peninsula, mainly near its junction with the mainland and at the upper end of the shore protection work built in 1889. For a mile along the westerly end of the body of the peninsula pronounced erosion occurred. The old pile jetties normal to the shore have disappeared, and the old pile protection near them now stands at least 75 feet out from the shore line. A cutting of probably 50 feet occurred for a part of the distance. A matter of interest is that the cutting away of the bluff bank has uncovered many large trees, very well preserved, which formerly must have grown on ground at about the mean level of Lake Erie. Above this buried forest growth the present forest of large trees has grown.

There appears to have been no erosion along the remainder of the peninsula, except at the old pile jetty at the eastern extremity, where severe erosion has occurred. The advance of the northeasterly shore line of the peninsula, and also the accumulation of sand just above the north pier, continue as heretofore.

Objects.—The objects of the improvement made are—

1. To protect the harbor from severe winds from the east and northeast.

2. To obtain and maintain a channel between deep water in the harbor and the open lake, 16 feet deep at low water and of navigable width.

3. To prevent the filling up and damage to the harbor by keeping the peninsula intact.

Present works.—The present works, which require to be maintained, consist of—

1. A breakwater lying in a north and south direction from the main shore to the south side of the entrance channel.

2. A pier on the south side of the entrance channel nearly east and west in position.

3. A pier on the north side of the entrance channel nearly parallel with and 360 feet distant from the pier above mentioned.

A north breakwater from the north pier to the main portion of the peninsula was also built, but it has fulfilled all its functions, is buried

accumulations of sand, and needs no further consideration or aintenance.

In 1883 there was also built a sand-catch jetty about 3,000 feet north of e channel entrance, but it never fulfilled its purpose and is badly ecked, and it is not proposed to repair it. It is hardly to be classed one of the harbor works.

The piers and breakwater consist of timber crib work, filled with ne and covered with a pine-plank deck.

The sand-catch jetty consisted of a single row of piles driven close gether and bound with oak walings.

A large amount of work was done in former years at the neck of the ninsula in building pile jetties, shore protection, crib work, sand ces, etc., but these works have either fulfilled their objects and are ried in the sands, or have been wrecked, and are not considered rthy of maintenance.

During the spring of 1896 some 2,000 young trees and cuttings were t out on the neck of the peninsula with a view of thickening the owth, arresting the drifting sand, and augmenting the width and ising the height of the neck, thus increasing its power to resist ero-n, and so lessening the liability of a breach in times of high water d severe storms. These trees as a whole did very well, particularly e locusts, which developed bushy tops, good roots, and a sturdy owth.

During the spring of 1897 2,400 more yellow-locust trees were planted, hich have thriven very well, and during the spring of 1898, 2,000 ney-locust trees and 200 willow cuttings were planted. This plant owth is regarded as an important part of the harbor works and is der constant care and maintenance.

Original estimate of cost.—The original estimated cost of the existing oject can not well be determined, and would be of little value, as the oject has been modified and changed many times, and the cost of nstruction and maintenance could hardly be separated.

The total amount expended by the General Government on the nprovement of Erie Harbor to June 30, 1897, was $910,462.91, and the mount expended during the fiscal year ending June 30, 1898, was 5,177.36.

REPORT OF OPERATIONS.

Repairs to piers and breakwater.—Only minor repairs to the decks of hese structures were made during the year. The repairs were begun April 25 and completed May 2, 1898, at a cost of $33.59 for materials nd $27.06 for labor. The structures have remained intact with these light repairs, but the superstructures of the older part of the north nd south piers and of the entire south breakwater are fast reaching a ondition which will require extensive rebuilding.

Dredging.—During the autumn of 1897 a shoal with only 15 to 16 feet f water over it developed in the outer channel outside of the piers. Under the existing contract with Carkin, Stickney & Cram, of Detroit, lich., the removal of this shoal was begun on May 2 and completed on lay 28, 1898. The total quantity of material dredged was 6,535 cubic ards, scow measure, and the cost of the dredging $1,110.95. The aterial was sand. This work again placed the channel in good con-tion throughout, and at the close of the fiscal year it was not less an 16 feet deep at low water for its full width of 300 feet.

Surveys.—No surveys were made during the year. An examination the entrance channel was made April 22–26, 1898. This examina-

tion showed the channel to be in good condition except across the shoal in the outer channel, which shoal was removed as above noted.

Observations of velocities of currents in entrance channel.—In compliance with instructions contained in a letter from the Chief of Engineers, dated April 16, 1897, a series of observations was made for determining the velocities of currents through the entrance channel between the piers. These currents are caused by the changes of water level in the lake and harbor, due to various meteorological causes, and the observations were for the purpose of determining the frequency and intensity of the currents and their influence on navigation through the channel.

The observations were begun on June 15 and concluded on November 30, 1897. A report of the observations, with a tabulation of the results obtained, was submitted on December 8, 1897, and is given herewith:

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., December 8, 1897.

GENERAL: In accordance with the instructions contained in your letter of April 16, 1897, I have the honor to submit the following report on current velocities between the piers at Erie, Pa., supplemental to my report of May 24, 1897, on the results of the survey of Erie Harbor, Pennsylvania, under the provisions of the act of June 3, 1896.

The observations of current velocities were made with rod floats 8 feet long over a base line 1,000 feet long, extending inward from the outer end of the south pier. The floats were timed at the extremities of the base line and also at its middle point, thus giving velocities over two 500-foot intervals and a check on the timing of floats.

The location of the course traversed by the floats is shown on the accompanying sketch and the results of the observations on the accompanying tables of velocities, one table for currents inward and one for currents outward. The observations began on June 15, 1897, and continued to November 30, 1897. During this time a constant watch was maintained during the hours of daylight, and whenever a current through the channel was noticeable the floats were set and observations made.

The flow was of course intermittent and in either direction, depending upon the change of water level due to wind or other meteorological causes. The light-house keeper and captain of the life-saving station, who live at the pier and are well conversant with the current movement through the channel and who assisted throughout the season in taking the observations, state that "the current changes every hour or two; it runs in, then stops, then runs in again. Sometimes it turns and runs out, then turns and runs in again. The current runs curiously; it will run for an hour, then stop, then run in on the north side and out on the south side."

The duration of flow in one direction was variable, ranging from less than one hour, sometimes only a few minutes, to several hours, and averaging about one hour.

The number of times the current was observed was 60 during the hours of daylight for a period of one hundred and sixty-eight days. Only well-defined currents were tested with the floats. Assuming that well-defined currents occur as frequently at night as in the daytime, we would have 120 well defined flows of current in one hundred and sixty-eight days, and at an average duration of flow of one hour, such currents would prevail in the channel about 3 per cent of the time.

The tables show that the currents are moderate as a rule, and that the current inward from the lake is about twice as rapid on an average as the current outward toward the lake.

Basing calculations upon the percentage of time that currents prevail as shown above, the observations indicate that currents exceeding 3 miles per hour are inward and occur rarely—only a small fraction of 1 per cent of the time; currents between 2 and 3 miles per hour are generally inward and occur less than 1 per cent of the time; currents between 1 and 2 miles per hour are generally inward and occur less than 1 per cent of the time; and currents less than 1 mile per hour, which are the ruling currents outward and the most prevalent currents inward, occur about 1 per cent of the time.

The velocities obtained on November 5 and 6 are remarkable, and were secured most opportunely during the severest storm of the season. The light keeper at the pier says it was "the strongest current he has seen for some years."

This series of velocity observations was undertaken because of a complaint that the present entrance channel is too narrow, causing at times dangerously swift currents. Near the end of my report of May 24, 1897, on the survey of Erie Harbor, Pennsylvania, occurs this paragraph:

"If a careful study of conditions should show conclusively that the entrance channel is too narrow, the above outlined project would be changed by replacing the south pier by one farther south."

The channel between the piers at Erie is 390 feet wide at the outer end of the south pier, narrowing to 350 feet at its narrowest part, as shown in the accompanying sketch. The velocity observations lead to the conclusion that strong currents—viz, currents of 3 miles or more per hour—are a rarity and not such as could be called dangerous to vessels of the types prevailing on the lakes and engaged in commerce at Erie.

Accidents to vessels due to currents in the entrance channel have been rare and never of a serious nature. Once in a while, averaging, perhaps, once a season, a tow barge will sheer into the piers, due to the currents, and receive slight damage or slightly damage the piers, but steam vessels properly handled are not liable to such accidents and do not meet with them.

Moreover, it is very questionable if any reasonable widening of the entrance channel at Erie, Pa., which is now one and a half times as wide and commodious as the generality of lake harbor entrances, would reduce the current velocities materially.

I, therefore, would deem it inadvisable and unjustifiable to change the project outlined in my report by a provision for a wider entrance channel.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

bservation of current velocities through entrance channel at Erie Harbor, Pennsylvania.

CURRENTS OUTWARD.

Date.	No. of float.	Distance traversed.	Time.	Velocity per hour.	Remarks.
1897.				*Miles.*	
ne 20	1	500	14-17	0.39	Set float 200 feet from north pier; drifted to north pier after going 500 feet.
28	1	500	16-54	.33	Set in mid-channel; drifted to north pier after going 500 feet.
29	1	1,000	12-18	.92	Set in mid-channel.
29	2	1,000	11-55	.94	Do.
ly 10	1	300	17-54	(a)	Stopped at 300 feet, turned about, and reached starting point in 13 minutes.
11	1	1,000	5-15	2.16	Squally; wind southwest.
27	1	1,000	15-22	.74	Wind southwest; fresh.
27	2	1,000	14-55	.76	Do.
30	1	1,000	23-03	.49	Wind southwest; moderate.
30	2	1,000	23-26	.48	Do.
ug. 2	1	500	41-44	.14	No positive current.
7	1	75	11-46	.07	Stopped; no positive current.
15	1	1,000	11-21	1	Squally; wind southwest.
29	1	1,000	11-58	.95	Wind southeast; moderate.
29	2	200	4-26	.51	Ran same time as No. 1; drifted to north pier after going 200 feet.
31	1	1,000	32-20	.35	Wind south; moderate.
ept. 5	1	400	23-20	.20	Went about 400 feet and stopped.
9	1	500	71-55	.08	Stopped at middle range.
19	1	50	49-25	.01	Went 50 feet and came to pier.
24	2	500	35-20	.20	Went 50 feet farther, then turned, and came to starting point.
30	1	1,000	24-20	.46	
ov. 4	1	1,000	12-57	.88	Light southwest wind.
15	1	1,000	16-08	.70	Moderate southeast wind.
Mean				.58	

a Not appreciable.

Time covered by observations, 168 days.

mber of times velocity was less than 1 mile per hour	20
mber of times velocity was between 1 and 2 miles per hour	1
mber of times velocity exceeded 2 miles per hour	1
	22

faximum velocity, 2.16 miles per hour.

Observation of current velocities through entrance channel of Erie Harbor, Pennsylv

CURRENTS INWARD.

Date.	No. of float.	Distance traversed.	Time.	Velocity per hour.	Remarks.
1897.				*Miles.*	
June 16	1	1,000	13-24	0.84	Set float 40 feet south from north pier.
16	2	1,000	12-14	.93	Set float 100 feet south from north pier.
July 8	1	500	8-08	.70	Stopped 200 feet west of middle range.
14	1	1,000	13-21	.85	South wind; light.
19	1	1,000	9-22	1.21	Southeast wind; light.
19	2	500	4-57	1.16	Went about 50 feet from second range.
23	1	1,000	14-12	.80	West wind; fresh.
Aug. 4	1	1,000	5-35	2.04	Stopped at last range.
4	2	1,000	5-54	1.98	Weather squally.
10	1	1,000	4-22	2.61	Wind southwest; moderate.
10	2	1,000	5-33	2.05	Do.
12	1	1,000	26-39	.43	Wind northwest; moderate.
27	2	1,000	40-25	.29	Wind south; fresh.
Sept. 2	1	1,000	17-20	.65	Northeast wind; light.
13	1	1,000	34-07	.33	Set 100 feet from north pier.
13	2	1,000	27-18	.42	Set 150 feet from north pier.
16	1	1,000	4-20	2.63	West wind.
16	2	1,000	4-33	2.51	Squally.
Oct. 3	1	500	7-04	.80	Went 50 feet past second range.
3	2	500	8-02	.71	Went 75 feet past second range.
7	1	500	27-36	.20	Stopped at middle range.
12	1	1,000	6-22	1.78	Strong southwest wind.
12	2	1,000	6-28	1.75	Set in mid-channel.
16	1	1,000	5-05	2.23	Fresh northwest wind.
16	2	1,000	5-05	2.23	Set in mid-channel.
22	1	1,000	12-16	.92	Wind southwest; light.
22	2	1,000	13-10	.86	Do.
Nov. 5	1	1,000	2-00	3.79	Wind southwest; strong.
6	1	400	1-11	3.84	Went to south side of channel.
9	1	1,000	4-00	2.84	Wind northwest; squally.
9	2	1,000	3-56	2.90	Do.
10	1	1,000	6-37	1.72	Wind southwest; fresh.
11	1	500	1-48	3.16	West wind; moderate gale.
21	1	1,000	16-39	.68	Wind southwest; fresh.
25	1	1,000	15-45	.72	Wind southwest; moderate.
26	1	1,000	6-38	1.71	Wind southwest; moderate gale.
29	1	1,000	5-22	2.12	West wind; a gale.
29	2	1,000	5-19	2.13	Do.
Mean	.....	.....	.....	1.07	

Time covered by observations, 168 days.

Number times velocity was less than 1 mile per hour.....
Number times velocity was between 1 and 2 miles per hour.....
Number times velocity was between 2 and 3 miles per hour.....
Number times velocity exceeded 3 miles per hour.....

Maximum velocity occurred during severe westerly gale on Lake Erie November 5 and 6, 3.8 per hour.

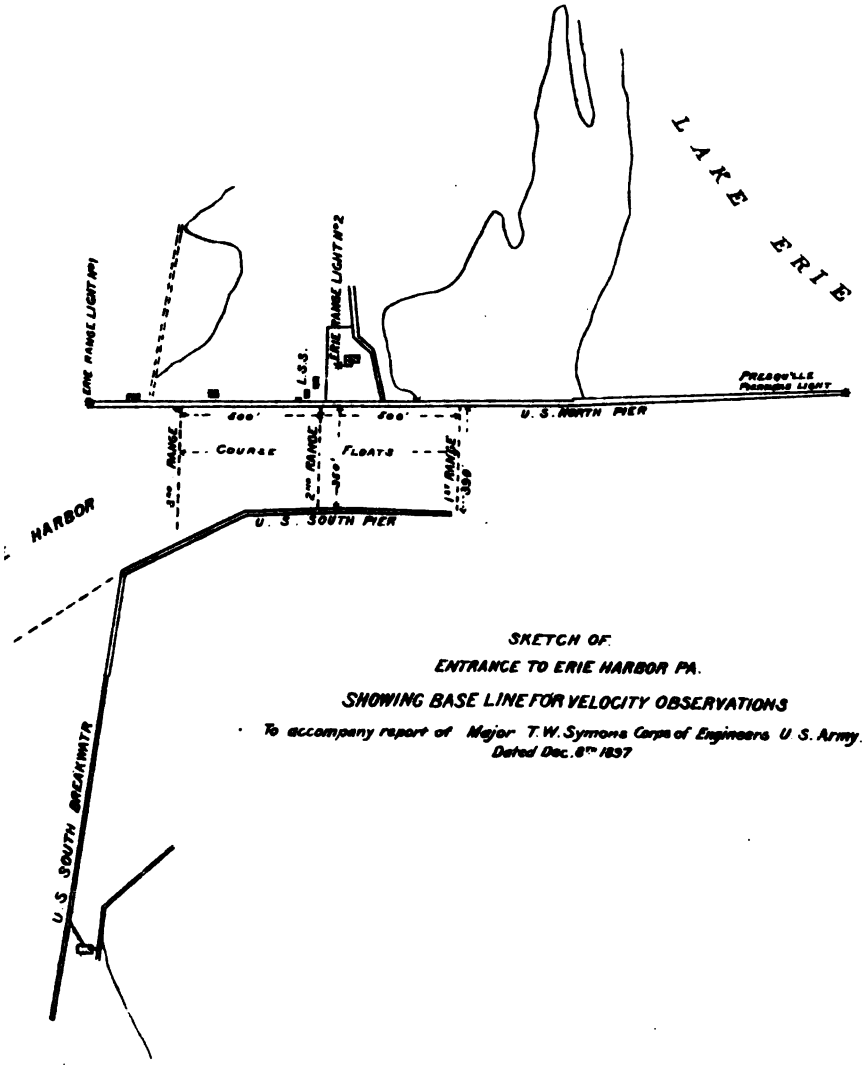
Tree planting on the neck of the peninsula.—Continuing the begun in 1896, 2,000 honey-locust trees were planted on the neck o peninsula, April 12 to May 6, 1898. About one-half of these trees set out between those planted in former years, with a view to ma the growth more dense. Others were set on bare spots above main portion of the neck and others along the narrow strip of the at its junction with the body of the peninsula. At the latter loc 200 willow cuttings, donated by the commandant of the Pennsyl Soldiers' and Sailors' Home, were also planted.

The cost of planting was as follows:

Trees, 2,000.....
Manure, 44 cubic yards .....
Labor .....

Total .....

The trees planted during the past two years have grown vigor This is especially true of the locusts, and therefore the locust was c for planting this spring.



SKETCH OF
ENTRANCE TO ERIE HARBOR PA.
SHOWING BASE LINE FOR VELOCITY OBSERVATIONS
To accompany report of Major T. W. Symons Corps of Engineers U. S. Army.
Dated Dec. 8th 1897

U S ENGINEER OFFICE
BUFFALO, N Y

Eng 55 3

PRESERVATION OF PRESQUE ISLE PENINSULA.

The watchman was on duty throughout the year patrolling the peninsula. No serious depredations were committed and only a few small fires occurred during the year. In addition to his other duties, the watchman has been instructed to watch the effects of erosion on the shores of the peninsula and to make reports thereof periodically.

Occupation of Presque Isle Peninsula.—For several years efforts have been made by parties to secure rights of occupation or possession of lands on the peninsula of Presque Isle. In 1895 "An act conveying to the city of Erie certain water lots and land on the shores of Presque Isle Bay" was introduced in the legislature of the State of Pennsylvania, but failed of enactment.

Resort to the State legislature was made because the promoters of the proposed act believed that the title of the United States to the peninsula lands was not indefeasible. The history of this title is outlined in documents incorporated in this report.

In June and August, 1896, letters were sent to the Chief of Engineers by the mayor of the city of Erie, Pa., in the interest of the city or of parties purporting to act in that interest, in the endeavor to obtain certain claims and rights of occupation upon the peninsula of Presque Isle, forming the outer limits of the harbor of Erie, Pa. The primary object sought was the establishment of a picnic ground at "Big Bend," on the bay side of the peninsula, opposite the city.

The matter was referred to this office for report, which report was made under date of August 12, 1896. Under date of August 18, 1896, the Secretary of War denied the request in a letter, of which the following is a copy:

WAR DEPARTMENT,
Washington, D. C., August 18, 1896.

SIR: Referring to previous correspondence on the subject and replying further to your letter of June 25, 1896, urging that the citizens of Erie be permitted to use a portion of the peninsula of Presque Isle as a pleasure ground, I beg to inform you that the matter has been carefully investigated by Maj. T. W. Symons, Corps of Engineers, who submits a report unfavorable to the proposition. The Acting Chief of Engineers concurs in the views of Major Symons, and states that "there are several serious objections to granting the request of the mayor of Erie, some of which are of a legal nature, while others relate to the stability of the peninsula and the safety of the harbor. These objections are well founded, and this office concurs in the opinion of Major Symons that the request of Mayor Saltsman should not be granted."

In view of the foregoing, the Department is constrained to deny the request.

Very respectfully,

JOSEPH B. DOE,
Acting Secretary of War.

Hon. ROBERT J. SALTSMAN,
Mayor of Erie, Pa.

In March, 1897, efforts to secure lands on the peninsula were renewed, and two bills were introduced into the legislature of the State of Pennsylvania, one of which was a repetition of the bill introduced in 1895. The attention of the War Department was called to these efforts by this office, and on April 14, 1897, the Secretary of War sent the following letter to the governor of Pennsylvania:

WAR DEPARTMENT,
Washington, D. C., April 14, 1897.

SIR: By section 14 of an act of the general assembly of Pennsylvania approved April 2, 1868, entitled "A further supplement to an act to incorporate the city of Erie," the city of Erie was given the "supervision and control" of the peninsula of Presque Isle (then the property of the State of Pennsylvania), with power to lease the same and apply the proceeds thereof to the marine hospital in said city, "but without power to sell or convey or cut any live timber or underbrush, or to author-

ize the same to be done, or to authorize any act that may have a tendency to affect injuriously the stability of the peninsula, the object and intent being that the said peninsula shall forever remain in its present condition, so far as may be necessary for its present preservation and that of the harbor of Erie depending thereon."

This section further provides that the "Commonwealth hereby reserve the right at any time hereafter to annul the privileges hereby granted and to resume the absolute control of said peninsula for military or other public purposes."

In the following year, by an act of the general assembly, approved February 4, 1869, entitled "A supplement to an act incorporating the Marine Hospital of Pennsylvania, at Erie" the said section 14 was "so far amended as to place the supervision and control of said peninsula in the power of the board of directors of the Marine Hospital of Pennsylvania * * * and the said board of directors is hereby empowered to exercise such supervision, disposition, and control of the same, by leasing or otherwise, as to them should be deemed for the best interests of said hospital."

It was further provided that if the same should be accepted by said board of directors of the marine hospital, then the marine hospital should "hold the same by and under the conditions" of section 16 of the act incorporating the hospital, approved March 22, 1867, which provides:

"SEC. 16. That the said marine hospital corporation shall, within ninety days after its organization, cause to have surveyed and measured out the lands named in this bill, and the map of the same shall be filed with the surveyor-general, whose duty it shall be to issue a patent to said hospital corporation for the same from the Commonwealth by the said company merely paying the lawful office fees, and said hospital company shall not hold or enjoy the lands donated to them by the Commonwealth until the provisions of this section are complied with."

This section refers to lands which had been granted to the hospital by this act of incorporation of the hospital.

The provision of said section 16 having been complied with by the marine hospital, a patent was issued on October 18, 1869, granting said peninsula (described therein by metes and bounds, and as containing 2,024 acres) to said marine hospital, to have and to hold the same "forever for the purposes specified" in said act of February 4, 1869, and in said act of March 22, 1867, "so far as the last-named act relates hereto."

By an act of the general assembly of May 11, 1871, the sum of $30,000 was appropriated for the purpose of fitting the hospital building for the reception of patients and paying the debts of the corporation, upon this condition, inter alia:

"That the said marine hospital corporation shall convey to the United States of America all title it may have to the peninsula of Presque Isle obtained from the State of Pennsylvania by act of February 4, 1869, entitled 'A supplement to an act incorporating the marine hospital at Erie, to be held by the United States as near as may be in its present condition, and only for the purposes of national defense, and the protection of the harbor of Erie, but in all other respects to be subject to the civil and criminal jurisdiction of the State of Pennsylvania; and the consent of the State of Pennsylvania is hereby given to such transfer, only for the purposes and under the limitations hereinbefore mentioned."

In accordance with this proviso, and within the time specified by the act, the marine hospital, by deed executed May 25, 1871, conveyed to the United States of America "all the estate, right, title, interest, property, claim, and demand whatsoever of them, the said Marine Hospital of Pennsylvania, in law or equity or otherwise, of into or out of" said peninsula "to be held by said United States as near as may be in its present condition and only for the purposes of national defense and for the protection of the harbor of Erie; to have and to hold all and singular the premises hereby remised and released, with the appurtenances, unto the said United States of America." This deed was recorded in the recorder's office of Erie County on August 18, 1871.

An act of Congress, approved May 27, 1872, authorized the Secretary of War to accept the said peninsula "to be held by the Government of the United States for the protection of the harbor of Erie: *Provided*, That the deed conveying the same shall not be received until the title to the same is complete and indefeasible, nor unless the acceptance shall be recommended by a board of officers of the Corps of Engineers appointed by the President."

It appears that the acceptance of the peninsula was recommended by a board of officers of the Corps of Engineers, convened in accordance with the foregoing provision, on July 9, 1873, but that owing to the opinion of the Department of Justice, that the title tendered was not "complete and indefeasible," the same was not accepted at that time.

By the river and harbor act approved August 5, 1886, the Secretary of War was authorized and directed to receive and accept the title to said peninsula "*as tendered by the said marine hospital*, agreeably to the provisions of an act of the legislature of the State of Pennsylvania, approved May 11, 1871; *and provided further*, that $22,500 of said sum (i. e. the sum appropriated for continuing improvement of Erie

harbor) shall not be expended until the aforesaid title shall be accepted by the Secretary of War."

Under date of December 14, 1886, the Secretary of War accepted the title to said peninsula by directing that the same be entered upon and taken possession of in behalf of the United States, and under this authority the land was entered upon and taken possession of in behalf of the United States on January 27, 1887.

In a report dated March 25, 1897, Maj. Thomas W. Symons, the United States engineer officer at Buffalo, N. Y., calls attention to an effort of certain parties purporting to act in the interest of the city of Erie to obtain some claim upon said peninsula, and he inclosed with his report a copy of a bill which has been introduced in the general assembly for this purpose by Mr. Gibson, the senator from the Erie district. In his report Major Symons says:

"It has, I think, always been the belief of engineers, as it is my belief, that the preservation of this peninsula, with the timber growth thereon, is in the highest degree important for the preservation of Erie Harbor, and it seems to me desirable that it should remain entirely under the control of the General Government, which has assumed the responsibility of preserving this harbor."

It would seem, therefore, that the title of the United States to this peninsula is not regarded as complete and indefeasible, and as it seems to have been the intention of the general assembly of Pennsylvania, as expressed in said act of May 11, 1871, that the peninsula should remain entirely under the control of the General Government for the purposes specified therein, I have the honor to request that you will submit the matter to the general assembly of Pennsylvania in your recommendation that an act be passed confirming and vesting in the United States a complete and indefeasible title to said peninsula, as the same is described in the deed from the Marine Hospital of Pennsylvania to the United States.

With highest respect, I remain, your obedient servant,

R. A. ALGER, *Secretary of War.*

Hon. DANIEL H. HASTINGS,
Governor of the State of Pennsylvania, Harrisburg, Pa.

On March 11, 1898, the mayor of the city of Erie again applied, by letter, to the Secretary of War for permission to use a portion of the peninsula as a pleasure ground. The application was referred to this office for report, which report was made under date of April 19, 1898. On April 29, 1898, the Secretary of War denied the request in the following letter:

WAR DEPARTMENT,
Washington, D. C., April 29, 1898.

SIR: I have the honor to acknowledge the receipt of your letter of 11th ultimo, stating that the city of Erie desires to lease for a pleasure ground that portion of the peninsula of Presque Ile known as "Big Bend."

In reply I beg to inform you that it appears a similar request was made by you in 1896, which, after a thorough investigation by the local engineer officer, was denied by the Secretary of War, for the reason that there were several serious objections to granting the request, some of which were of a legal nature, while others related to the stability of the peninsula and safety of the harbor. The matter has again been referred to Maj. Thomas W. Symons, the local engineer officer, who reports adversely, and calls attention to his former report upon the subject, in view of which the Department feels compelled to adhere to its previous action, and regrets that it must deny your request.

Very respectfully,

R. A. ALGER,
Secretary of War.

Hon. ROBT. J. SALTSMAN,
Mayor of Erie, Pa.

REMARKS AS TO ERIE HARBOR.

The last river and harbor act required a new survey and preparation of plans and estimates for improvement of Erie Harbor. This was assigned to my charge, and a report upon it was submitted under date of May 24, 1897, and printed in House Doc. No. 70, Fifty-fifth Congress, first session, and in annual report of the Chief of Engineers for 1897, pages 3237–3245.

As this report provides for a new project and makes new estimates of cost, it is not deemed necessary to make any further estimate for work or appropriations here.

Money statement.

July 1, 1897, balance unexpended		$36,122.21
June 30, 1898, amount expended during fiscal year		5,177.36
July 1, 1898, balance unexpended		30,944.85
July 1, 1898, outstanding liabilities	$100.00	
July 1, 1898, amount covered by uncompleted contracts	700.14	
		800.14
July 1, 1898, balance available		30,144.71

Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	(*)
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Statement of appropriations and allotments made for improving harbor at Erie, Pa., from 1823 to the present time.

1823, allotment	$150.00	March 3, 1871	$29,000.00
May 26, 1824	20,000.00	1871, allotment	10,000.00
May 25, 1826	7,000.00	June 10, 1872	15,000.00
March 2, 1827	2,000.00	June 23, 1874	20,000.00
May 19, 1828	6,223.18	March 3, 1875	80,000.00
March 3, 1829	7,390.25	August 14, 1876	40,000.00
March 2, 1831	1,700.00	June 18, 1878	25,000.00
July 3, 1832	4,500.00	March 3, 1879	25,000.00
March 2, 1833	6,000.00	June 14, 1880	25,000.00
June 28, 1834	23,045.00	March 3, 1881	20,000.00
March 3, 1835	5,000.00	August 2, 1882	20,000.00
July 2, 1836	15,122.80	July 5, 1884	50,000.00
March 3, 1837	15,000.00	August 5, 1886	87,500.00
July 7, 1838	30,000.00	August 11, 1888	83,000.00
June 11, 1844	40,000.00	September 19, 1890	40,000.00
August 30, 1852	30,000.00	1891, received from sales	4,716.89
1864, allotment	15,000.00	July 13, 1892	40,000.00
June 23, 1866	36,961.00	August 18, 1894	10,000.00
March 2, 1867	25,000.00	May, 1897, repayment	1.00
1868, allotment	40,000.00		
1869, allotment	22,275.00	Total	946,585.13
June 11, 1870	20,000.00		

Abstract of proposals.

No.	Name and address of bidder.	Dredging per cubic yard.
		Cents.
1	Carkin, Stickney & Cram, Detroit, Mich	a17
2	Breymann Bros., Toledo, Ohio	24
3	James Rooney, Toledo, Ohio	25
4	Hingston & Woods, Buffalo, N. Y	22

a Acceptance recommended.

Contracts in force at close of fiscal year.

Contractors.	Date.	Date of approval.	Date of beginning.	Date of expiration.
Carkin, Stickney & Cram, Detroit, Mich	Mar. 8, 1898	Mar. 24, 1898	May 2, 1898	Nov. 30, 1898

REMARKS.—For dredging in entrance channel of Erie Harbor.

* New project reported.

COMMERCIAL STATISTICS OF ERIE HARBOR, PENNSYLVANIA.

Arrivals and departures of vessels for the year ending December 31, 1897.

Vessels.	Arrivals from—				Departures to—			
	Home ports.		Foreign ports.		Home ports.		Foreign ports.	
	Number.	Tons.	Number.	Tons.	Number.	Tons.	Number.	Tons.
Steam, sail, and barges	1,477	2,053,895	90	19,707	1,494	1,970,579	72	7,803

Greatest draft of vessels, 17½ feet.
Total arrivals and departures: Number, 3,133; tonnage, 4,051,984.
Increase of tonnage, 1897 over 1896, 417,142 tons.
Value of imports, $10,958.
Value of exports: By lake, $7,874; by rail, none.
Enrolled tonnage, port of Erie, 1897, 38,767.68 gross tons.
No new lines of transportation established.
Amount of revenue collected for year ending December 31, 1897, $5,210.99.

Receipts and shipments by lake.

[Tons of 2,000 pounds.]

RECEIPTS.

Articles.	1892.	1893.	1894.	1895.	1896.	1897.
Merchandise	87,491	68,374	86,120	82,329	123,387	228,383
Barley	1,900	1,825	9,640	3,716	3,399	19,617
Corn	147,256	210,770	74,252	77,276	191,621	260,290
Oats	.....	5,743	80	805	6,156	5,968
Rye	10,915	6,232	2,656	2,239	4,929	22,041
Wheat	237,630	101,051	67,665	53,315	169,305	154,203
Flaxseed	7,866	6,877	2,055	7,837	20,092	13,335
Flour	200,190	170,438	219,289	191,811	190,720	199,798
Malt	.....	.....	516	.....	.....	.....
Lumber	21,567	12,843	14,463	26,182	11,762	18,886
Laths	343	135	93	14,443	300	715
Shingles	20	.....	.....	.....	22	144
Stave bolts	863	.....	.....	.....	.....	.....
Poles	.....	.....	111	157	.....	.....
Ties	.....	.....	909	.....	.....	526
Iron ore	720,504	549,205	721,514	907,258	925,071	1,442,756
Pig iron	4,432	.....	741	5,783	13,810	11,085
Copper	704	2,410	14,495	21,572	31,987	36,751
Lead	.....	5,544	11,535	1,593	5,333	15,212
Limestone	5,626	12,991	.....	.....	.....	.....
Plaster	1,784	21,294	14,614	1,201	2,430	1,331
Scrap iron	.....	.....	.....	.....	18,780	.....
Steel billets	.....	.....	.....	.....	681	.....
Produce	12	.....	.....	.....	.....	.....
Total	1,399,103	1,175,732	1,240,748	1,397,517	1,719,785	2,422,041

SHIPMENTS.

Anthracite coal	428,785	338,973	474,887	537,628	492,563	515,801
Bituminous coal	133,675	78,387	265,037	223,489	179,640	234,432
Pig and manufactured iron	400	.....	.....	.....	.....	.....
Merchandise	110,592	45,918	89,187	87,323	81,731	123,677
Stone	550	.....	.....	.....	.....	.....
Total	673,952	463,278	829,111	858,440	753,934	873,910

The following table, compiled from the reports of the Chief of Engineers, gives the combined number of arrivals and departures and the tonnage of arriving and departing vessels for the past ten years:

	1888.	1889.	1890.	1891.	1892.
Arrivals and departures	2,111	2,488	2,694	2,437	2,139
Tonnage	1,852,601	2,351,485	2,480,853	2,343,566	2,409,965
	1893.	1894.	1895.	1896.	1897.
Arrivals and departures	1,677	2,687	2,936	3,100	3,128
Tonnage	1,701,542	3,069,545	3,823,672	3,634,842	4,051,984

N N 2.

IMPROVEMENT OF HARBOR AT DUNKIRK, NEW YORK.

Original condition.—The harbor at Dunkirk is naturally a simple indentation of the south shore of Lake Erie. It lies between Point Gratiot on the west and Battery Point on the east. Between the two points is a distance of about 9,600 feet, and the maximum breadth of the bay behind the line of the two headlands is 3,600 feet. The general natural depth of water in the bay was about 10 feet. The bay is underlaid with rock at an average depth of 15 to 16 feet. The object of the improvement is to form an artificial protected harbor in the indentation or bay above described.

Project for improvement.—The original project was adopted in 1827 and, with its subsequent modifications, provided for the construction of a pier running out from the west shore of the indentation and a detached breakwater parallel with the pier and about 2,000 feet distant from the city front. An opening between the two structures provided a harbor entrance through which a channel leading to the docks was to be deepened to 13 feet. By 1832 the sum of $28,439.84 had been expended on the original plan, and the breakwater was then 2,564 feet long and the pier 1,400 feet long. Subsequently various improvements and repairs were made. In 1848 the breakwater was demolished by storms.

In 1870 the question of the improvement of this harbor was referred to a board of engineers. The board recommended a plan which provided for a detached breakwater 2,860 feet long, one part of which, 2,300 feet long, was to be nearly parallel with the shore, the other part, 560 feet long, to be nearly parallel with the axis of the channel entrance and terminating at the position of the day beacon.

This breakwater and the pier already built were to form the harbor, and the old channel was to be enlarged to 170 feet wide and 13 feet deep.

All the works now existent at Dunkirk have been built in accordance with this plan. The project adopted by Congress and provided for by the river and harbor act of June 3, 1896, consists of completing the breakwater as before planned by the addition of 310 feet to its eastern end, adding the channel arm, 560 feet long, and in addition thereto dredging an entrance channel and a harbor basin, containing in all about 65 acres, to a depth at mean lake level suitable for vessels draw-

ıg 16 feet. The estimated cost to complete this project was $408,258, ivided as follows:

xtension of breakwater, channel arm, construction of day beacon, and repairs to existing structures	$74,900
redging for channel and basin to a depth of 17 feet, to secure a navigable depth of 16 feet	306,650
ontingencies, engineering, etc	26,708
Total	408,258

The total amount expended on the harbor by the General Government to June 30, 1897, was $563,418.23.

The amount expended during the fiscal year ending June 30, 1898, ras $257,100.

The law of June 3, 1896, having authorized the entering into contract or the radical improvement of Dunkirk Harbor, specifications for this work were prepared, and on March 22, 1897, bids for the work were opened and the contract was let to Edward J. Hingston, Buffalo, N. Y.

The work contracted for at Dunkirk consists of the excavation of about 555,000 cubic yards of material, of which it is estimated that 475,000 cubic yards is mud, sand, gravel, etc., and 80,000 cubic yards is rock; the replacement of 680 linear feet of the decayed superstructure of the west pier with concrete; the building of a timber crib structure along the eastern edge of the proposed entrance channel; and the extension of the breakwater to the east 310 feet, which extension will consist of a timber and stone foundation surmounted by a concrete and stone superstructure. Illustrations showing the different constructions as planned were published in the last annual report. As explained in the report of operations herewith the plans for the concrete and stone superstructure on the breakwater extension were somewhat changed in construction.

The annual report for this harbor for 1896 contained an account and description of existing works and the condition of the harbor. (Chief of Engineers' Report, 1896, p. 3108.)

Under date of August 11, 1897, a supplemental contract with the contractor, Mr. E. J. Hingston, was entered into to increase the depth over the greater portion of the harbor basin from 17 feet as provided in the original contract to 18 feet, in order that vessels drawing 16 feet might at mean lake stages have 2 feet of water under their keels. This supplemental contract also provides for increasing the depth of water in the entrance channel from 17 feet as provided in the original contract to 19 feet, in order that vessels drawing 16 feet might at mean lake stages have 3 feet of water under their keels, thus reducing the liability to strike bottom in heavy seas. These changes were deemed essential to carry out the general project which requires the harbor to be suitable for vessels drawing 16 feet, and it was in the interests of economy that the additional depth should be secured at the same time that the originally projected depth was secured.

Another supplemental contract was entered into with Mr. Hingston under date of January 26, 1898, for replacing 167 feet of old crib work in the west pier structure. Upon removing the wood superstructure from the extreme eastern portion of the pier to be concreted, the underlying cribs were found to be in such a condition that it was deemed unwise to place the concrete superstructure on them. The

111,018.7 cubic yards. The timber crib and concrete work
been started at the beginning of the fiscal year.

Basin and channel excavation.—Under the original contrac
April 15, 1897, about 65 acres of harbor basin and entrance
were to be deepened to 17 feet at mean lake level. A suppl
contract was entered into August 11, 1897, to increase the dept
channel excavation to 19 feet and of the basin to 18 feet, exc
reserved area in the extreme northeast corner of the basin whi
remain at the original projected grade of 17 feet below mean lal

In order to keep an accurate record of the work of different
the harbor basin was divided into eleven sections and the chan
five sections. Afterwards the two easterly basin sections were
and the area redivided into three sections, with a fourth in the
northeasterly corner. The final division of the work and the l
the basin and channel excavation are shown on the accompanyi
of Dunkirk Harbor.

At the beginning of the fiscal year five dredges and one drill b
in operation, with the requisite number of scows and tugs. Two
were added to the fleet during the season and two withdraw
November, 1897. On December 1, only one dredge remained
and on the fourth of that month it also suspended operations
winter.

Rock-drilling operations were begun on May 17, 1897, with
boat, and the plant was increased from time to time until A
when three drill boats were in operation. At that date one d
was found unsuited to the work and withdrawn, and operati
tinued with the other two until work was suspended for the w
December 1.

In order to commence work for the season of 1898 as soon a
ble, a channel was blasted through the ice to the west end of t
March 1 to 6, 1898, and drilling operations were resumed and
in progress. Dredging operations were resumed and are still
ress. Dredging operations were resumed by one dredge March
other dredges were added until on June 7 the fleet consisted
dredges and two drill boats with the necessary scows and tugs.
close of the fiscal year this fleet was still at work and the final

After very careful computations based upon the original survey, the following are the established official quantities of material to be paid for under the contracts:

	Rock.	Sand, etc.	Total.
	Cubic yds.	*Cubic yds.*	*Cubic yds.*
Original contract	73,429	469,498	542,927
Supplemental contract	46,388	54,208	100,596
Total	119,817	523,706	643,523

The total amount excavated and credited to the contractor as provided by contract up to and including June 30, 1898, is as follows:

	Rock.	Sand, etc.	Total.
	Cubic yds.	*Cubic yds.*	*Cubic yds.*
Original contract	107,758	383,021.8	490,779.8
Supplemental contract	35,303	28,159	63,462
Total	143,061	411,180.8	554,241.8

The conduct of the work has been closely observed. The positions of the drills and dredges for each day's run are a matter of record. The records of the inspector of dredging include gauge and weather observations; for each dredge the number of hours work and delay and the causes of delay, the number of scows loaded and unloaded, time each scow left for the dumping ground and time of its return, number of yards of material, and classification for each scow loaded.

At a recorded time during each day (with few exceptions) soundings were taken around the dredges, scows, and drill boats in the excavated area and to the adjacent natural bottom. These records are utilized as a basis for determining the amount of material excavated from below grade and represented in the scow measure, and for the purpose of verification of the total estimated place and scow measure and of the depths to sand and rock shown on the map of the original survey.

Briefly described, the excavated material consists of a sedimentary deposit of clay, sand, and gravel, underlaid either above or below the specified grades by a close-grained foliated blue shale, hard and compact in the interior of the reefs, but disintegrated about their surfaces. An effort was made by each dredge in succession to excavate the shale "in situ" after stripping the softer material. Each effort was abandoned after several expensive breakdowns of machinery.

The engineering methods employed in the work are to first remove the soft material overlying the rock, using drill scows, and then to remove the broken-up rock by the same dipper dredges. The nature of the rock renders it necessary in order to get "grade" to remove much more rock than is paid for.

Channel arm.—The channel arm of the breakwater was completed during the year. The construction details of this structure are shown on the drawing opposite page 3106 of the Annual Report of the Chief of Engineers for 1897. The structure was built as shown on the drawing, except that for 120 feet lakeward from its junction with the main breakwater, the depth of the cribbing was increased to 16 feet to conform to the depth to bed rock. The total length of this channel

arm is 581.6 feet, and it makes an angle of 43° 57′ with the axial line of the breakwater.

The location of this channel arm required the removal of two crib lengths, or 60 linear feet, of the west end of the breakwater. These were removed by cutting the superstructure at the proper point and then shattering the structure by light dynamite charges distributed through it. The whole was then removed by dredging.

Excavation for the foundation of the channel arm was begun June 28 and completed August 16, 1897. For 120 feet lakeward from the breakwater a depression in the bed rock occurs. Borings were made in this area to a depth of 28 feet without reaching hard bottom. A trench was excavated to a depth of 23 feet through the soft material and back filled with rubblestone to a grade of 16 feet below mean lake level. Beyond this depression bowlders and crib débris overlying the bed rock were removed from the foundation area, and rubblestone deposited where necessary to bring the foundation to a grade of 8 feet below mean lake level. The construction of the cribs was begun July 8 and completed August 24, 1897. The grillage bottoms were assembled and bolted in the water, as no convenient launching area was obtainable. The several courses conforming to the specifications were then added and securely bolted.

The cribs were successively placed in position over the prepared foundation, securely fastened at both ends by cross turnbuckles and anchors, sunk to mean lake level, and filled with stone. The superstructure was then built continuous over the sunken cribs. The structure was fully completed October 30, 1897. The structure as completed is 8 feet above water level, with a flat deck 14 feet wide on the harbor side, and a timber slope on the lake side extending from the deck to the lake face 1 foot above water level. At the outer end, 30 feet of superstructure is built with vertical walls to the height of the deck planking and surmounted by a pyramidal day beacon, the apex of which is 16 feet above mean lake level.

The outer end of the superstructure is protected with 3 fenders of white oak timber, 6 by 12 inches, extending across the full front and for 7 feet on the sides. The corners are further protected with iron straps, ½ by 6 inches, spiked to the fenders. The top ends of the slope timbers for 264 feet were painted with two coats of carbolineum avenarius, the remainder was rounded on the top angle and covered with galvanized iron sheets one-eighth inch thick, securely spiked to the timbers. At the reentrant angle at the junction with the main breakwater the slopes were brought together and thoroughly bonded.

Since the completion of this structure comparatively quiet water is noted in the inner channel, its effect being to partially impound the waves deflected from the west pier across the channel entrance.

REPAIRS TO WEST PIER.

This work implies:

First. The removal of the decayed superstructure, including the stone filling to 2 feet below mean lake level, over a section of the pier 500 feet long beginning at the shore, and a section 180 feet long 110 feet farther east.

Second. The examination and repair, where necessary, of the underlying cribs.

Third. The deposition "in situ" upon the prepared foundation and inside of molds, of a subaqueous base of concrete monoliths of a least length of 20 feet, completely covering the underlying cribs.

Fourth. The building of a concrete superstructure on the concrete ase.

The construction details are illustrated at page 3106 in the Annual eport of the Chief of Engineers for 1897. The work of removing the ld superstructure began at the shore end on July 2, 1897. Previous) this date the contractor was employed in assembling plant, collect- ıg material, etc. Until July 26 the work was confined exclusively to ıe removal of the old superstructure. The first concrete was deposited ı this date.

The underlying cribs were found to be in irregular alignment and ırface, and difficulty was experienced in making the sides of the con- rete molds sufficiently tight to exclude wave pulsation. Adjacent to he shore line, within the beach limits, the base sections of concrete ere laid dry, temporary cofferdams having been constructed of sand ags and the pits pumped out.

In deep water temporary protection cribs 3 feet in width were sunk ın the lake side a few feet from the molds, and the mold boards braced o them. This method of protecting the work answered very well until he fall, when it was abandoned and $1\frac{3}{4}$ inches square steel bars were lriven in the lake bottom, to which the molds were fastened by staples.

The plant for handling the concrete work consisted of a stone crusher, ubical mixer with a capacity of 2 cubic yards, and a double track nar- ow-gauge tramroad built along the bay side of the pier, and a derrick ar of proper gauge to cover the four tracks, with a friction-geared oisting engine and a "stiff-legged" derrick mounted upon it.

The material used for the concrete was first class in every respect, nd the greatest care was taken to see that each batch of concrete was nade of proper proportions. The mixer delivered the concrete into a heet-iron skip with hinged bottom, which was transported to the work, ifted by the derrick, placed in position, and unloaded through the novable bottom.

The general method adopted for laying the subaqueous concrete was o build up one corner of the base and then deposit the skip loads on his mass above the water surface, working the concrete over the edges rith shovels. When the base was completed the superstructure sec- ions were built up by placing proper molds, inside of which the skip oads were deposited and spread to a thickness of about 6 inches and horoughly rammed, the sides being smoothed with a long narrow pade before the mass compacted. Stones taken from the crib filling f hard and durable quality and selected sizes were incorporated in the eart of the wall, in conformity with the specifications. The interstices 'ere filled with concrete and rammed to thoroughly unite the mass.

Concrete for the parapet was unloaded on a platform constructed on)p of the mold frames and shoveled to position in layers. The top of anquet, parapet, and base were manipulated to smooth surfaces with- ıt the use of mold boards.

The 500-foot section of this concrete work adjoining the shore was)mpleted by the 5th of November, 1897. On October 9 the removal ! timber superstructure was commenced on the 180-foot section, and ter many delays the forms were set for the subaqueous concrete base ı November 5 and concreting commenced. A severe storm that ght not only washed out the deposited concrete, but wrecked three nall defective cribs in the lake wall of this section. The exposed cribs ere secured and work suspended for the winter.

On February 25, 1898, a supplemental contract was made with the ntractor, Mr. E. J. Hingston, for a crib 167 feet long, 14 feet wide,

and 7 feet deep, to replace the defective cribs in the lake wall. The construction of this crib was commenced on April 26, 1898, and completed May 21, 1898. The foundation was prepared and the crib was sunk May 31, and filled with stone by June 6, 1898.

The cement used on the work is Atlas Portland, made near Allentown, Pa., and it is carefully tested before use in the work. Up to June 1, 1898, 219 samples had been tested, for which 3,547 briquets were made. The neat cement briquets developed the following average tensile strength per square inch:

In twenty-four hours, 384 pounds; in seven days, 638 pounds; in twenty-eight days, 724 pounds; in ninety days, 770 pounds; and in six months, 806 pounds.

The briquets made of one part of cement and three parts standard crushed quartz sand developed the following average tensile strength per square inch:

In seven days, 195 pounds; in twenty-eight days, 264 pounds; in ninety days, 267 pounds; in six months, 264 pounds.

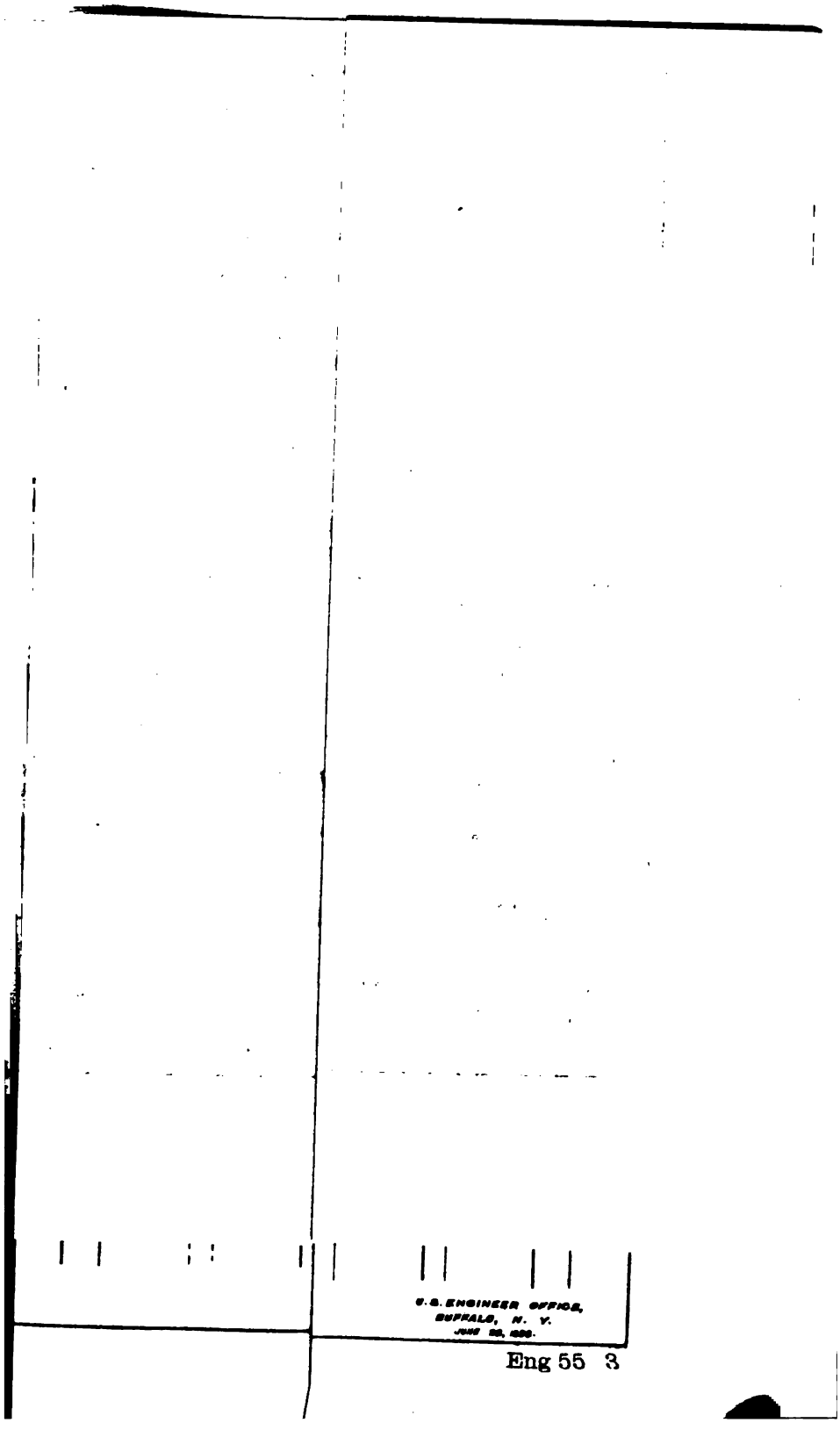
The number of briquets broken after ninety days and six months was not large.

Everything is now ready for completing the concrete superstructure on the 180-foot section of the west pier repair work. The contractor is preparing his plant, and it is expected that within a short time after the close of the fiscal year the work will be completed.

Breakwater extension.—Under the project and the existing contract the breakwater is to be extended to the eastward 310 feet. The superstructure of this extension is to be a concrete shell filled with stone. The construction details for this work are shown opposite page 3106 of the Annual Report of the Chief of Engineers for 1897. The crib construction for this extension began August 6, 1897, and the cribs were completed August 24, 1897. The two cribs comprising the total length were 30 feet in width; one crib was 150 feet long and 10 feet deep, the other crib was 150 feet long and 6 feet deep. The cribs were sunk on October 27 and November 22, and were completely filled with stone by the 4th of December. Owing to a reef on the harbor side of the extension, which had but 6½ feet of water on it at the time the work was done, it was necessary to reduce the draft of the deeper crib before it could be towed into position. This was accomplished by securely lashing two scuttled scows alongside the crib to serve as pontoons. Tight boxes of the full area of the crib pockets were also submerged and wedged in the cribs. When the buoyancy of the submerged fleet was restored the draft of the crib was decreased from 7 to 5 feet, and it was then put in position.

At the close of operations for the season of 1897 the cribs were left without protection to the exposed stone filling which was at an elevation of about 2 feet below mean lake level. Storms during the winter were of frequent occurrence, but the structure weathered them without shifting either in alignment or surface. Sixteen of the posts for supporting the concrete shell of the superstructure at the slope angle were, however, washed away, and must be replaced at the expense of the contractor.

Operations upon the superstructure were renewed on June 9, 1898. Upon the contractor's request, concrete foot blocks were substituted for the corresponding subaqueous concrete deposited in situ in the original plans. These concrete foot blocks were made 10 feet long, 4 feet wide, and 3 feet high, and when placed conform to a top elevation of 1 foot above mean lake level. Each of the blocks for the lake front weighs about 8 tons. The harbor-wall blocks each weighs about 7 tons.



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The work of placing these blocks was under way at the close of the fiscal year.

There is submitted herewith a view of operations on the several works in progress under the existing contract.

Surveys.—No surveys were made during the year except those incidental to the authorized works of improvement.

The ice conditions during the winter of 1897–98 were unfavorable for extended examinations of the basin and channel area. In February the established ranges for basin and channel excavation were verified by precise measurements made on the ice. To determine the location of the 19-foot curve at the channel entrance, a hydrographic survey was made June 3, 1898. Soundings were taken on six lines 100 feet apart, ranged at right angles to the east range of the channel. The soundings cover the area of the outer-channel section and extend approximately 100 feet on each side of channel.

The work was done by regular employees without incidental expense.

Repair of structures.—The only repairs made during the year were minor repairs made between November 1 and 15, 1897, by hired labor. The work consisted in replacing some of the lower waling on the west pier, and 100 linear feet of lower waling on the main breakwater.

The top ends of 650 linear feet of slope timber at the east end of the breakwater were painted with one coat of iron-ore paint mixed with the best quality of boiled linseed oil, at a cost of $38.95.

REMARKS.

It is expected, under the existing contracts and with the money available, to complete the project during the present season's operations. There is, therefore, no need for further appropriations under the existing project.

Money statement.

July 1, 1897, balance unexpended		$398,919.65
June 30, 1898, amount expended during fiscal year		257,100.00
July 1, 1898, balance unexpended		141,819.65
July 1, 1898, outstanding liabilities	$500.00	
July 1, 1898, amount covered by uncompleted contracts	129,685.40	
		130,185.40
July 1, 1898, balance available		11,634.25

Statement of appropriations and allotments for improving the harbor at Dunkirk, N. Y., from March 27, 1827, to the present time.

March 27, 1827	$3,000.00	March 3, 1873	$48,132.95
May 19, 1828	6,000.00	June 23, 1874	35,000.00
March 3, 1829	9,812.75	March 3, 1875	35,000.00
April 23, 1830	1,342.75	August 14, 1876	18,000.00
March 2, 1831	7,102.50	1879	2,500.00
July 3, 1832	10,200,00	June 14, 1880	10,000.00
June 28, 1834	4,000.00	July 5, 1884	10,000.00
March 3, 1835	10,988.43	August 5, 1886	20,000.00
July 2, 1836	11,000,00	August 11, 1888	15,000.00
March 3, 1837	15,000.00	September 19, 1890	20,000.00
July 7, 1838	10,000.00	July 13, 1892	20,000.00
June 11, 1844	5,000.00	August 18, 1894	20,000.00
August 30, 1852	30,000.00	June 3, 1896	10,000.00
March 2, 1867	100,000.00	June 4, 1897	398,258.00
1869	2,000.00	May, 1897, repayment	.50
July 11, 1870	25,000.00		
March 3, 1871	25,000.00	Total	962,337.88
June 10, 1872	25,000.00		

Contracts in force at close of fiscal year.

Contractor.	Date.	Date of approval.	Date of beginning work.	Date of expiration.	Remarks.
Edward J. Hingston, Buffalo, N. Y.	Apr. 15, 1897	Apr. 26, 1897	May 5, 1897	Oct. 15, 1898	For harbor excavation and breakwater extension.
Do. a	Aug. 11, 1897	Aug. 28, 1897	Aug. 28, 1897	.....do	Harbor excavation for increased depth.
Do. a	Jan. 26, 1898	Feb. 25, 1898	Apr. 26, 1898	.....do	Replacing defective cribs in west pier.

a Supplemental to contract of April 15, 1897.

COMMERCIAL STATISTICS OF DUNKIRK HARBOR, NEW YORK.

Arrivals and departures of vessels for the year ending December 31, 1897.

Vessels.	Arrivals from home ports.		Departures to home ports.	
	Number.	Registered tonnage.	Number.	Registered tonnage.
Steam	93	3,242	88	3,0[illegible]
Sail	8	4,205	8	4,2[illegible]
Total	101	7,447	96	7,2[illegible]

Total arrivals and departures, 197; tonnage, 14,745.
Increase in tonnage from 1896, 2,585 tons.
Amount of revenue collected for year ending December 31, 1897, rail, $231.47.
Value of imports, all rail, $3,313.61.
Value of exports, none.
No new lines of transportation established.
Receipts by lake: Lumber, 10,664 tons; stone, 14,826 tons; fish, 8 tons; total, 25,498 tons.
Shipments by lake, none.
Enrolled tonnage, port of Dunkirk, N. Y., 98.20 tons, gross.
Greatest draft of vessels, 11 feet.
The following table gives the total of the arrivals and departures and the tonnage of the vessels arriving and departing for the past ten years, as compiled from the Reports of the Chief of Engineers:

	1888.	1889.	1890.	1891.	1892.
Total of arrivals and departures	32	68	100	96	9[illegible]
Tonnage of arriving and departing vessels	12,302	17,189	22,496	24,465	13,75[illegible]

	1893.	1894.	1895.	1896.	1897.
Total of arrivals and departures	137	76	69	43	19[illegible]
Tonnage of arriving and departing vessels	19,158	18,763	15,650	12,160	14,74[illegible]

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IMPROVEMENT OF BUFFALO HARBOR, NEW YORK.

ORIGINAL CONDITION OF THE HARBOR.

Buffalo Creek was the original harbor of the port of Buffalo. In its original condition it was shallow and closed by a gravel bar for most of the year.

PROJECTS FOR IMPROVEMENT.

A statement as to the former projects under which the work at Buffalo s been carried on by the General Government is given in the Annual port of the Chief of Engineers for 1896, page 3110.

The works built by the United States which require care and supervision are the north and south piers protecting the entrance to Buffalo eek and the Blackwell Ship Canal, and an outer breakwater 7,608.6 t long, built of timber and stone. The superstructure on 3,879.13 t of this length has been replaced with concrete.

There is also a sand-catch pier extending out from the lake shore to e established pierhead line, a distance of 1,148 feet.

The project in force for the further improvement of Buffalo Harbor is:

(1) To maintain existing structures, making the requisite minor repairs d replacing the wooden superstructure of the breakwater with concrete when necessary.

(2) To build an extension of the breakwater from its present southern d to Stony Point, leaving the necessary openings for the convenience commerce.

(3) To extend the sand-catch pier to the established pierhead line.

s long as only minor repairs are needed, the cost of maintenance of isting structures is estimated at $2,000 per year. There is a stretch 1,015 feet of wooden breakwater lying between the two concreted rtions which will soon require to have its superstructure replaced th concrete. This is the portion which gave the most trouble in building and where the foundation and superstructure are most insecure. ne timber crib portion at the outer end of the south pier, 350 feet in ngth, requires a new top course of superstructure and decking.

The next river and harbor act should provide for replacing this 1,015 et with concrete and for the repairs on the south pier. It is estimated at the concrete superstructure of the 1,015 feet of the old breakwater ll cost $125 per foot, or $126,875, and the south pier repairs $5,000; tal, $131,875.

Two years of other repairs will cost $4,000, making an estimate for e cost of maintenance for the immediate future of $135,875.

In accordance with the authority contained in the river and harbor t of June 3, 1896, the work of extending the breakwater to Stony int and the sand-catch pier to the pierhead line was advertised, and e contract was awarded to Hughes Bros. & Bangs, of Syracuse, N. Y. Under this contract the work of dumping stone in the rubble-mound eakwater was started May 19, 1897, and of building cribs for the mber-crib breakwater July 23, 1897, and has continued ever since cept during the winter. Work on the sand-catch pier was started ay 25, 1897, and completed October 22, 1897.

Under the head of "report of operations" are given the details of the rk of repair, maintenance, and new construction.

The total amount expended by the United States on the improvement Buffalo Harbor to June 30, 1897, was $2,722,733.15.

The amount of money expended by the United States during the cal year ending June 30, 1898, was $153,457.07.

REPORT OF OPERATIONS.

Repairs to existing structures.—No work was done on the north and uth piers during the year, except that about 20 linear feet of waling the south pier, which was crushed by the steamer *North West* running o the pier, was fully repaired by the owners of the vessel.

No repairs were made on the breakwater, the old parts of the wood superstructure, viz, 1,015 linear feet built in 1873–1877 and 1,485 linear feet built in 1884–85, remaining intact after the considerable repairs made in 1896.

Under authority of the Secretary of War, dated December 14, 1895, arrangements were made with dredging contractors operating in Buffalo Harbor to dump clean rock and hardpan dredgings along the front of the breakwater. This placement was continued throughout the year, the material being dumped close along the lake face, between Stations 20 and 40, to form a revetment for the crib work.

To further raise this protection along the portion of old timberwork, built in 1873–1877, so as to gradually get it into position for rebuilding with concrete, the arrangements made with contractors last year to place such masses of rock as they might have for disposal immediately adjacent to the breakwater were continued during this fiscal year. This riprap, which is composed of large blocks of stone, is all handled with a derrick and placed carefully in position in front of the breakwater. For a long distance it reaches above water level.

	Cubic yards.
Riprap placed and paid for, fiscal year 1897	317.26
Riprap placed and paid for, fiscal year 1898	526.60
Total	843.86

Cost, at $1.20 per cubic yard, $1,012.63.

Besides the riprap handled by a derrick and paid for, there was deposited from dump scows without expense to the United States about 100,000 cubic yards of rock and other good filling material.

Dumping dredgings.—A constant supervision was maintained over the dumping of dredgings from the various works of excavation carried on by the State and city authorities and private parties in Buffalo River, the City Ship Canal, and the Erie Canal. Work of this kind is constantly going on, and the disposal of the dredgings is a matter requiring constant and serious consideration in order that the interests of navigation may not suffer. With the exception of the clean rock and hardpan dredgings deposited along the breakwater, all dredgings were required to be dumped on the authorized dumping ground in Lake Erie at the mouth of Smoke Creek, where a buoy was maintained to regulate the dumping.

Sounding scow.—The necessity of constant and elaborate investigation by soundings of the condition of work as it progresses on breakwater construction made it imperative to secure a sounding scow suitable for conducting this work with rapidity and accuracy. A scow was therefore designed which would admit of readily making and locating soundings over cross sections of the rubble-mound breakwater and the trench excavated for the timber-crib breakwater. In order to secure as many cross sections as possible without changing the boat's position the scow was built with two hulls, each 10 feet wide and 120 feet long, separated by an open space 10 feet wide, thus forming a catamaran. By this arrangement four parallel cross sections 10 feet apart can be sounded from one position of the scow.

Two deck houses, each 8 by 10 feet in size, were built on the scow, one to serve as a plotting and computing room and one as a storeroom for lines, etc. The scow is provided with a crank capstan at each end for handling anchor and mooring lines. The hulls of the scow were built of 3 feet depth only, in order that the deck might be as low as possible to facilitate sounding operations, and were provided with suitable trussing and bracing to secure stiffness.

The scow was built under agreement with Charles A. Dennis, Buffalo, Y., the lowest bidder, in September and October, 1897, at a cost of ,890.90. It proved to be adequate in strength and to fully meet the quirements of the work.

Steam-inspection vessel.—In conducting the works of improvement at uffalo and elsewhere in the district it is essential to have at command steamer fitted for service on the open lake, in harbors, and on canals. ıe best boat available by charter at a moderate cost was employed at ıe beginning of the fiscal year. It proved to be unfit for service in ıe lake except during calm weather, and also unfit to withstand the ıgh usage to which a small vessel is liable to be subjected in a crowded ırbor like that of Buffalo. The latter fact was demonstrated when ıe chartered yacht was run down and sunk on September 28, 1897, by ı excursion steamer at the Buffalo Harbor entrance. The engineer of ıe yacht was drowned and the officer in charge, assistant engineer, ıd captain of the yacht narrowly escaped drowning.

A good, sturdy vessel of the tug type, with proper housing and ;commodations, being deemed most suitable for the service required, ıthority was asked and obtained to build one. The vessel as built is good, plain, substantial steel steamer, 60 feet length of keel, 70 feet ngth over all, 15 feet beam, and 8 feet depth of hold, supplied with a ›mpound engine 12-inch and 22-inch by 16-inch stroke, a propeller of ; feet diameter, and a water-tube boiler for a working pressure of 150 ›unds, at which pressure the engine must develop 200 revolutions per inute.

Bids were opened December 15, 1897, bidders submitting their own ›signs, and an agreement was entered into December 20, 1897, with ıe Craig Shipbuilding Company, Toledo, Ohio, the lowest bidder, for ›nstructing the vessel at a cost of $11,970.

The vessel was delivered at Buffalo on April 24, and placed in com- ission and accepted after a final inspection and speed trial on May 2, 98, which fully met the specifications.

Surveys.—No special surveys were made during the year. Examina- ons incidental to the authorized works of improvements were made as llows:

Of the north and south United States piers and the channel between ıem in December, 1897.

With the data thus obtained a new map of the piers and channel was epared.

Sand-catch pier extension.—The work of extending the sand-catch ier to the established harbor line was begun by the contractors, ughes Bros. & Bangs, on May 25, 1897. The work was delayed by ›ugh weather, but was fully completed on October 22, 1897. The ngth of the extension was 278 linear feet, making the total length of ıe structure 1,148 linear feet. The extension is a pile pier, built of orway-pine piles 35 feet long, driven close together in two parallel ›ws 8 feet apart, and penetrating 15 feet into the bed of the lake. he tops of the piles are 6 feet above water level. The pile walls thus ›rmed are firmly bound with Norway-pine walings 12 inches below ıeir tops on the inner and outer faces of the piles and bolted to them ith screw bolts. The walls are further bound together with tie-rods feet apart. At the outer end a cross wall similarly constructed closes ıe end. The inclosed space is filled with stone to the top of the alings.

The total cost of the extension was $6,632.44, or $23.85+, per linear ›ot.

During the past winter the outer 50 feet of the structure was canted over, due to scour and ice pressure, so that the piling stands inclined at an angle of about 45° instead of vertical. The structure is, however, intact and its utility is in no way impaired.

Breakwater construction.—This work consists of the construction of the extension of the Buffalo breakwater southward to Stony Point, leaving the necessary openings for the convenience of commerce, in accordance with the existing project, which is based upon the report of the Board of Engineers of July 1, 1895, and the river and harbor act of June 3, 1896. The revised plans governing the location and construction are those given in Major Symons's modification of plan and location for breakwater at Buffalo, N. Y., dated April 6, 1896, and approved by War Department indorsement of August 11, 1896.

These plans provide for the construction of a section of breakwater 9,700 feet in length, beginning at a point even with the southerly end of the old breakwater but 250 feet lakeward therefrom, so as to leave a fair-weather entrance, and extending thence southerly in a straight line. The northerly 5,000 feet of breakwater to be of the approved rubble-mound type, which in its outer form is modeled upon the Delaware Breakwater, and the remaining 4,700 feet to be of the approved timber-crib type, mounted upon an artificial foundation extending down to solid rock. Another section of timber-crib breakwater 2,800 feet in length is provided for, which extends out from the shore at Stony Point in a northwesterly direction, leaving an entrance 600 feet wide between the two structures.

A map of Buffalo Harbor, showing the location of the breakwater extension, is herewith; also drawings showing typical cross sections of the rubble-mound and timber-crib structures composing the extension.

The work is under the continuous-contract system, and is being done by Hughes Bros. & Bangs, of Syracuse, N. Y., under contracts of January 27 and 28, 1897, and supplemental contract of April 26, 1898.

Rubble-mound breakwater.—Construction was begun on May 19, 1897, on the rubble-mound breakwater, and at the beginning of the fiscal year 13,861.27 tons of small rubblestone had been placed on the northerly 1,000-foot section in small ridges along the lake side and harbor-side footings of the proposed structure.

Previous to the actual work of construction the axial line of the breakwater structure had been marked by large range targets located at Stony Point and on the existing breakwater, and clusters of three piles each had been driven on the axial line and on the extreme side lines for the northerly 1,000-foot section. A system of anchor buoys had also been set for mooring scows while placing stone in the work.

Similar range piles had been set by July 3, 1897, for the second 1,000-foot section, and the building up of the footing ridges with rubble-stone was carried on continuously over the two sections. The placing of gravel hearting between the footing ridges was begun on July 8, the gravel being supplied in large dump scows, into which it is loaded by a dredge excavating it from the bed of Niagara River off the foot of Ferry street, Buffalo, about 5 miles from the breakwater site. The gravel is of most excellent quality, being composed of particles of sound stone varying from 3 to 4 inches diameter down to ordinary coarse sand. On account of the great swiftness of the water in the Niagara River between Lake Erie and the point where it is dredged special arrangements were required for towing. At first two to four of the small Buffalo Harbor tugs were used to tow up a loaded scow. Then a large tug from Detroit was brought to the work, but it failed

o satisfactorily meet the requirements. Then the method was tried f anchoring a dredge at the head of the rapids and using it as a sta- ionary engine to pull up the gravel scow by a cable run down the iver. This did not succeed. At last a tug was devised suitable for he work, and it, the *Chas. F. Dunbar*, is now in commission and easily rings up a large scow containing 550 cubic yards of gravel. The tug s large and powerful, and its engine and propeller wheel are suited or use in the swift water of the river.

The work of building up the rubble-mound structure was thence- orward carried on by building up the footing ridges and depositing he gravel hearting between them, care being taken to keep the two perations in proper correlation, so as to secure as nearly as possible he designed cross section of the mound.

By the 1st of August, 1897, the work in the first and second 1,000-foot ections had advanced to the point where large rubblestone and cap- ing stone were essential to further progress. The contractors had up o this time obtained rubblestone of small size only from the débris iles along the rock cut of the Erie Canal just west of Lockport, N. Y. The large rubble and capping stone was to be supplied from quarries eing opened by the contractors at Windmill Point, Ontario, Canada. These quarries are near the Canada shore of Lake Erie and about 4 niles from the site of the breakwater. Delays in opening them mate- ially delayed progress on the first and second 1,000-foot sections, and ot until August 17 was the first load of large rubble received and henceforward it was supplied in only limited quantities. It was there- ore apparent that in order to advance the work as much as possible t would be advisable to begin the construction of the third 1,000- oot section, and thus admit of placing the small rubble from Lockport, which was being regularly supplied. Range piles were therefore set for he third 1,000-foot section, and when the setting was completed on August 23, 1897, the rubble-mound construction was begun in that ection.

During the remainder of the season of 1897 rubble-mound construc- ion progressed slowly in the three 1,000-foot sections. Several range iles were carried away by storm and replaced September 10 to 15. This delayed work somewhat, but the limited supply of large rubble- tone and gravel was a serious drawback. The large rubblestone as ast as supplied was placed in the first 1,000-foot section, with the object f raising at least a portion of this section above water and beginning the lacing of the large capping stone on the lake slope as quickly as pos- ible. Persistent urging was necessary to induce the contractors to ush the delivery of all classes of stone and of gravel, but nevertheless he delivery was slow. On September 23 the rubble-mound structure ad reached an elevation of 15 feet below mean lake level for a length of 00 feet in the northerly 1,000-foot section, and the work of covering the ravel hearting with large rubblestone was begun. Preferably this overing would have been done at 5 feet higher elevation, but the late- ess of the season and danger from fall storms necessitated protecting he gravel hearting from storm-wave action, which is probably effective o 15 feet or more depth.

While the rubblestone was being placed over the gravel the lake lope in this limited section was also roughly prepared to receive the rge capping or revetment stone. On October 23 the first scow load— nd the only one during the season of 1897—of this stone was received, nd the placing of the footing course of the revetment at the prescribed vel of 15 feet below mean lake level was begun. These stones average

over five tons in weight, and must necessarily be lowered in place with a derrick. The derrick furnished by the contractor was improvised on an old dredge and it proved inefficient. The placing of the scow load of about 60 blocks of stone, weighing 383.4 tons, was not completed until October 27.

The lack of supply of this stone, the lack of plant for handling them, and the stormy weather, all contributed to the failure to place more of the revetment during the remainder of the season. A storm on November 5 carried away 12 range piles, and unfavorable weather otherwise contributed to slow progress during November. The last load of rubblestone on hand was placed on December 4, when work stopped for the winter.

At the close of operations for the season of 1897 the top of the rubble mound structure had reached an elevation of 5 to 10 feet below mean lake level in the first, or northerly, 1,000-foot section; 14 to 20 feet below in the second 1,000-foot section, and 20 feet below in the third 1,000-foot section. One scow load of 383.4 tons of revetment stone had been placed between stations 4 and 5, on the first 1,000-foot section.

During the winter the contractors built four large decked scows, three of which were fitted with modern and efficient derricks and hoisting engines designed to handle the large stone on the rubble-mound work.

The preliminary work for resuming operations for the season of 1898, such as resetting the range piles, all of which were carried away by ice during the winter, planting anchor buoys removed at the close of last season's operations, fitting out scows, etc., was done during the first half of April.

Construction work was begun on April 18, operations being confined to the placement of gravel and large rubblestone supplied from the Canadian quarries during the balance of the month of April.

On the opening of the Erie Canal, on May 9, the delivery of small rubble from Lockport was resumed. This was used for continuing the leveling up of the lake slope in the first 1,000-foot section, and on May 14 the placing of the large stone revetment on this prepared slope was resumed.

Extremely favorable weather during May and June gave unusual opportunity for rapid progress. The supply of large rubble and capping stone was, however, limited, and progress was slow in consequence. The rubble-mound construction was carried on in the three 1,000-foot sections, and at the close of the fiscal year the rubble-mound structure was in the following condition:

First 1,000-foot section: For nearly its entire length the mound is 5 feet above water surface, and the lake slope has been about two-thirds revetted with large stone for 310 linear feet.

Second 1,000 foot section has an elevation from 5 feet below water surface to the level of water surface.

Third 1,000-foot section has an elevation of 10 to 15 feet below water surface.

The stone which has so far been put in the rubble-mound breakwater is from four sources:

First. From the spoil banks along the Erie Canal, near Lockport, N. Y. This is brought to the work in canal boats and unloaded directly therefrom on the work, except during prolonged bad weather, when the canal boats are unloaded into dump scows, which are then towed to the proper place and dumped.

Second. The main source of supply is from the contractors' quarries,

Vindmill Point, Canada. This stone is brought to the work both in ıp scows and on deck scows.

hird. A considerable quantity of stone has been procured in the oval of the wrecked shore arm of the breakwater, which shore arm abolished by the approved plans for the breakwater extension to ny Point. Its removal to a depth of 22 feet is a requirement of the ıting contract. The contractors placed the stone removed from this shore arm into the rubble-mound structure.

'ourth. The Buffalo Dredging Company is employed in deepening channel of Buffalo Creek above the Louisiana street bridge by avating rock therefrom. The breakwater contractors have purchased ıe of this stone, which has been put into the rubble mound.

'he following is a summary of the material placed in the rubble-und structure during the fiscal year 1898:

›ble stone from Lockport, N. Y	tons..	44,345.88
›ble stone from wrecked United States breakwater arm	do...	20,912.45
›ble stone from Buffalo Creek, New York	do...	14,744.18
Total from United States	do...	80,002.51
›ble stone from Windmill Point, Canada	do...	62,050.22
ge capping stone from Windmill Point, Canada	do...	3,251.10
Total from Canada	do...	65,301.72
vel from Niagara River, New York	cubic yards..	92,279.00

Timber crib breakwater.—The section of timber crib breakwater, to be ıut 2,800 feet long, jutting out from Stony Point and reaching to the in southern opening, is first to be built complete, and the first work the timber crib breakwater was therefore the construction of the ›s of reduced section adapted to the shoal water at Stony Point.

'he framing of cribs for this portion of the work was begun on July 1897; excavation for crib foundations was begun July 26, 1897, and shore crib at Stony Point was sunk in place August 26, 1897. A nch 4 feet deep was excavated in the natural clay and bowlder for-tion of the point, and upon this the crib was founded.

'our additional cribs of similar depth and similarly founded were ced in extension of the initial crib. These five cribs, each 60 feet g, 16 feet wide, and 4 feet deep, constitute the cribbing of the smallest uced section of breakwater construction, 300 feet long, and carry the ıcture out to about 5 feet depth of water. A crib 120 feet long, 16 t wide, and 8 feet high was next sunk in extension and forms the ›bing of the second reduced section. The inner 40 feet of this crib s founded upon the natural clay and bowlder formation excavated to epth of 8 feet. At this point, 370 feet from the shore and of the ıber crib work, the bottom formation became too soft to bear the ›, and the trench was excavated to a depth of 25 feet and back filled h gravel, over which was placed a layer of foundation stone about eet thick leveled to the proper grade. Upon this the outer 80 feet the crib was founded.

'his crib was sunk on October 19, and as the contractors lacked the ınt necessary for deep-trench excavation, no more cribs could be ıced during the season of 1897.

'he building of timber superstructure, 8 feet high over 420 feet of bbing, was begun on September 11. On October 23, 180 linear feet d been fully completed. Superstructure construction was continued the remaining 240 linear feet until November 5, when a severe storm ifted the outer end of the cribbing 1 foot out of line. This displace-

ment was due to contractors not properly protecting the outer end of the cribbing.

Owing to the lateness of the season, the contractors decided to postpone rectification of the displaced cribbing until spring, and no more superstructure work was done.

During November a rubble wall, 122 feet long, 14 feet wide at bottom, 6 feet wide at the top, and built up to the level of the timber crib superstructure, 8 feet above mean lake level, was constructed across the weather beach from the shore end of the timber-crib structure to the crest of the beach.

The building of timber cribs at the contractors' yard at Tifft Farm was stopped on December 11, 1897, and all operations closed for the season.

Operations for the season of 1898 were begun on April 11, when superstructure construction was resumed on the 240 linear feet above mentioned, next to the shore. This was fully completed May 31. On May 25 the first crib of the season of 1898 was sunk in place. This crib, 60 feet long, 24 feet wide, and 12 feet deep, and five similar cribs, all of which were sunk in place by June 15, form the cribbing for the third reduced section, 360 feet long. All of these cribs were founded upon the prescribed artificial foundation, consisting of gravel back filled into a trench excavated 25 feet deep through the natural clay and bowlder foundation to the underlying rock, with a layer of rubble stone about two feet thick forming the level foundation immediately under the cribs.

The construction of superstructure over the third reduced section was begun on June 13, and at the close of the fiscal year had been practically completed.

On June 15 the first crib, 60 feet long, 30 feet wide, and 18 feet deep, of the fourth and last reduced section, was sunk in place, and at the close of the fiscal year one other similar crib, making 120 linear feet in all, had been placed, leaving seven cribs necessary to complete the placing of cribbing for this last reduced section.

The trench for the artificial foundation under cribs of first, second, and third reduced section was excavated by a dipper dredge. In the third reduced section this excavation was carried to the extreme depth practicable by the dredges of this type available. While the trench did not extend to rock bottom, the clay and bowlder formation was believed to be of sufficient firmness to insure stability when back filled with an average of 11 feet of gravel.

At the end of this third reduced section, however, the bowlders in the clay were becoming fewer in number and smaller in size, greatly reducing the bearing power of the stratum, and showing that the great bed of fine clay known to overlie bed rock along the remainder of the breakwater site had practically been reached.

The trench for the fourth reduced section, which begins 780 feet out from the Stony Point end, was therefore ordered to be excavated to bed rock.

For this work the large clam-shell dredge, specially designed and built by the contractors for the trench excavation, was needed. The building of this dredge was completed during the winter of 1897–98, and the dredge, named *Fin MacCool*, began operations on trench excavation March 23, 1898, but imperfections in details of machinery made changes and repairs necessary, and, together with other delays, resulted in the dredge not beginning regular and systematic work until April 27. From this date to the close of the fiscal year trench excavation progressed, but not rapidly, as delays for repairs still hampered progress.

Beginning at Station 780, the beginning of the fourth reduced section, the trench was excavated 30 feet deep, or practically to bed rock; thence out to Station 1585 the depth of the trench gradually increased to 54 feet.

When the plans of the work were under consideration a great deal of uncertainty existed as to the slopes at which the sides of the great trench excavated in the mud underlying the lake would stand. Opinions varied greatly. For purposes of estimate the slopes were fixed at 1 on 1, and for the standard crib 36 feet wide it was designed to excavate the trench with a bottom width of 50 feet. It is found, however, that the slopes of the trench stand at much steeper angles than 1 on 1, much to the gratification of those in charge, and it is practicable, without increasing the amounts of excavation, to widen the bottom of the trench, which will tend to give a greater stability to the structure. As this trench excavation is an important and interesting feature of the work, several cross sections showing the trench as actually excavated are given herewith.

The small amount of clay and sand left in spots upon the bottom of the trench overlying the rock, it is believed, will mingle with the gravel filling, and will not detract from the stability of the structure.

At the close of the fiscal year the trench excavation had reached a point 1,585 feet from the shore end at Stony Point.

ENGINEERING METHODS AND DETAILS IN BREAKWATER CONSTRUCTION.

LAYING OUT WORK.

On rubble mound.—The site of the breakwater is in the open waters of Lake Erie, which is there 30 feet deep, from its northerly end to a point 1,300 feet out from Stony Point. Thence shoreward the depth of water gradually and uniformly decreases until the shore is reached. All of the work is exposed to storms and heavy seas caused by the prevailing westerly winds. The laying out of the work therefore requires monuments and markings capable of withstanding severe wave action. The axis of the main portion of the construction, 9,700 feet long, is permanently marked by large targets set on the old existing breakwater structure and on shore at Stony Point. These targets are about 14,000 feet apart. Beginning at the extreme north end of the rubble mound portion, which is to be 5,000 feet long, the axis is further marked by piles carefully set on the axial line at 100-foot stations. At the extreme north end a row of 8 piles is set on the cross section at right angles to the axial line, the outer piles being at the extreme limits of cross section at the lake bottom and the intermediate piles at salient points. To these piles is also bolted a templet or profile, which shows the outline above water of the rubble mound as it is to be built. Similar templets are bolted to piles on cross sections at 500-foot intervals along the site of the rubble mound, and piles are also set on the side lines, on the lake and harbor sides, at 500-foot intervals, with intermediate piles wherever they are found to be required for properly marking the side lines. To further secure ranges for the proper depositing of material in the rubble mound structure, lines are stretched from the tops of any set of side piles across the structure and tags suspended from these lines at desired points. The lines work freely at one end over a pulley on the pile head, and weights attached to the free end of the lines keep them taut and prevent their breaking when the piles are swayed by the waves.

The piles are plainly marked with station numbers. By this system of ranges and stations the location for depositing every scow load of stone and gravel in the work can be closely determined; the depositing of the several kinds of stone and gravel can be done in proper sequence and a record kept of the location of each scow load.

On trench excavation and timber crib work.—This work is laid out similarly to the rubble mound. For the trench excavation piles are set on the side lines of the proposed trench at 500-foot intervals from established reference points, or at such intervals as are needed to properly locate the work. The coincident axial line of the trench and of the timber crib work, which is built upon the artificial foundation placed in the trench, is marked by permanent targets set on shore and on the completed breakwater structure. The location of the excavation work can thus be determined at all times by the measurement of coordinates to the axial line and to the side lines. This is done with a measuring wire fitted with floats which both support the wire on the water and graduate the wire in feet. Soundings in the trench, each scow load of gravel filling and foundation stone placed in the trench, and the subsequent work in building the timber crib structure are all located in a similar manner. The alignment of timber crib structure is further laid out by transit.

MEASURING AND PLACING MATERIALS.

In rubble mound.—The several kinds of material, small rubblestone, large rubblestone, gravel, and large capping stone, are conveyed to the work in vessels. A part of the small rubble, that coming from Lockport, on the Erie Canal, is conveyed in canal boats. The remainder of the rubblestone, both small and large, and the capping stone, is conveyed in dump scows and deck scows, and the gravel in dump scows.

All of these vessels, except gravel scows, are "weighed in," and are provided with glass water gauges, located amidships, in the bow, and stern of each vessel, for determining the displacement and tonnage of each load of material. Each scow and its load is identified by a "loading ticket," which records the light and loaded gauge readings, and the quantity and kind of material composing its load, at the place of loading, with date. The ticket accompanies the loaded scow to the work, and a check record of loaded and light gauge readings and of the kind and quantity of material and when and where it was placed is recorded on the ticket. These tickets afterwards form the basis for the reports and records of material. The capacity of the scows loaded to various depths is readily determined from displacement tables carefully prepared for each scow. These tabulated values are checked from time to time by actually weighing on track scales at the contractors' quarries loads of the different classes of stone before loading it upon the scows.

The scows loaded with material are held in place for unloading by lines leading to four or more anchor buoys, which are set at convenient points along the breakwater site. As soon as properly placed, the unloading of the scow proceeds as rapidly as possible. In the case of dump scows, the loads are dumped in the usual manner, but dump scows can only be used to a limited extent, as much of the construction will not admit of this method of deposit. In the case of deck scows and canal boats loaded with small rubblestone, the material is thrown into the water within designated limits by laborers.

In the case of large rubblestone, which comes in pieces weighing from 100 pounds to several tons each, the unloading is done with steam derricks.

The large capping stone is necessarily unloaded and deposited by e derricks, each stone separately.

The gravel is dumped from the dump scows after they have been refully set, and moored, if necessary, in position.

The process of building up the rubble mound is as follows:

Small ridges about 5 feet high of small rubble are first deposited ong the lake and harbor side lines on the natural lake bottom. The ıtervening space is then filled with gravel. The side ridges are then ıised another 5 feet by placing small rubble to the prescribed slopes, nd the intervening space is again filled with gravel. This process is ontinued until the rubble stone and gravel hearting have been raised ɔ within 10 feet of the water level (20 feet above lake bottom) when he gravel hearting is covered over with large rubblestone and the ıound raised above water by the continuous placing of large rubble. When the mound has reached the water surface it is ready to receive he large revetment stone. The belt of this stone, which begins at 15 eet below water level on the lake side and 10 feet below on the harbor ide and reaches to 5 feet below water level on both sides, is designated ıs the revetment. The slopes on which the revetment is to rest are irst leveled to the prescribed lines by depositing small rubblestone by ıand. The large revetment stone, blocks of which are quarried out ıpproximately cubical in shape, with one dimension as near 6 feet as ɔossible, are then lowered in place in juxtaposition as nearly as prac- icable, so as to fully cover the rubblestone behind them. This work s done without a diver, usually, and requires constant testing with ɔounding poles to insure proper placement. At times the water is suf- ıciently clear and the light favorable for seeing the stone with the ınaided eye down to the depth of about 10 feet, and under these con- litions the work is much simplified.

These favorable conditions of light are however not sufficient for the ıecessary examinations and inspections of the placement of the cap- ɔing stone. A water telescope was therefore constructed to aid in such nspection. The telescope tube is made of iron plates, $\frac{3}{16}$, $\frac{1}{8}$, and $\frac{1}{16}$ nch thick, riveted together and made water-tight. The tube is 12 feet ong, 12 inches in diameter at the object end and 4 inches diameter at he eye end, fitted with hooks for tackle used in raising and lowering, ınd handles, and painted black on the inside. A casting is riveted on he object end of the tube, which is provided with planed seats for a ılane object glass 13 inches in diameter and $\frac{1}{2}$-inch thick, and for the ubber packing and ring necessary to make water-tight joints.

When the revetment has been completed to its required height of 5 ɔet below water, the raising of the rubble mound by the further eposit of large rubblestone follows. The work is then more readily ıanaged, as it is practically all above water.

At this writing, July 1, 1898, the mound construction above water as only been commenced. The process of construction will, however, e as follows:

The rubblestone will be built up compactly, all interstices being lled by packing stone in them, and the slopes and top surface leveled ith small stone to receive the large capping stone. This large capping ɔne, which is the same as the revetment stone, will then be placed by ıe derricks as compactly as possible, and all interstices filled by fit- ng in them stones of the requisite size, so that the finished capping one will form a pavement of large masses of rock compactly laid. he templets will serve as a guide in laying the pavement to the quired grade and form.

At the close of the season's operations in December, 1897, a model of the 3,000 feet of rubble mound under construction was made, to show just what the condition of the work was at that time.

Complete data for the model were obtained from cross sections 10 feet apart, which were taken over the whole length of the mound just before the close of operations. The model was made in three sections, each representing 1,000 feet of structure on a scale of 10 feet to 1 inch. The base consists of a wood frame covered by a top board, in which saw cuts were made to locate the cross sections 10 feet apart. The cross sections were tranferred from drawings to thin boards, and the outline of each cross section thus obtained was cut out of the boards. The boards set on edge in their proper location in the saw cuts gave an outline of the rubble-mound structure. The spaces between the cross sections were then filled with plaster. The plaster surface thus obtained was then carefully modeled to conform to the cross-section outlines, and gave an excellent representation of the rubble mound. The portions of the cross-section boards not used were preserved, and by plotting on them the cross-section outlines at any future stage of the mound construction and placing them in their positions on the model, the new representation can be obtained by the addition and modeling of more plaster.

The water level is represented by wires stretched over the models, and the lake bottom formation to rock is painted in colors on the sides of the base.

DIFFICULTIES IN SUPPLYING GRAVEL.

A large amount of gravel is required for the rubble-mound structure and for back-filling the trench for the timber-crib structure. This supply is derived, thus far at least, from the extensive deposits of gravel on the bottom of Niagara River just above the International Bridge. The gravel is loaded into large dump scows of about 450 to 550 cubic yards capacity each by a dipper dredge. The scows must be towed on an average of 6 miles to the work. The first mile of this tow is up the Niagara River against a current of 3 to 5 miles an hour, and the second mile is against a current of 1 to 3 miles per hour. The remaining 4 miles of the tow are in Lake Erie.

At the beginning of operations in July, 1897, as many as four lake tugs were required to bring one scow fully loaded up the river. By leaving the bow pocket in the scows light, a single large lake tug succeeded in towing them, but one tug after another was disabled by the excessive strain on boiler and machinery. Subsequently two of the largest "river tugs" on the lakes were tried, but each broke down on first trial and made no further attempts. The contractors next tried towing the scows up the first mile by a traction cable operated by a dredge securely anchored. This also failed, as the cable fouled among the rocks on the river bottom and the strain broke the cable drum on the dredge. The construction work requires the delivery of gravel in large quantities, and as it requires some three hours for each tow, the gravel must of necessity be brought up as fast as the dredge can load it on the scows. Further experiments proved that the best results could be obtained by loading the scows, leaving one, usually the forward, pocket empty and employing one of the largest harbor tugs to tow them, until a tug could be built of sufficient power and proper design for the work. By this method a fair rate of supply was maintained during the season of 1897.

A large steel tug, the *Charles F. Dunbar*, was built during the winter

1897–98. This tug is supplied with compound engines of about 1,300 sepower and a propeller adapted to the swift water in the river, and proved ample for towing the scows, one at a time.

EXCAVATING AND FILLING TRENCH.

ll of the timber-crib breakwater must be founded upon a bed of vel or similarly good-bearing material, back-filled in a trench exca-ed to solid rock, through the bed of yielding clay which forms the ural lake bottom. This implies excavation to a depth of 50 to 80 , the depth of water being 20 to 30 feet, and the depth of the clay to rock being 30 to 50 feet; and further implies a plant specially pted to the excavation of the clay to the required depth of 60 to 80

dredge of the clam-shell type obviously fills the conditions implied, a large dredge of this type was therefore built by the contractors. his dredge, *Fin MacCool*, is a large one equipped with heavy modern chinery operating a clam-shell of 10 cubic yards capacity, and suffi-ntly seaworthy to remain on the site of the work, except during very ere storms. The dredge is held in position by cables leading to anchor buoys suitably located about 250 feet from the sides and n of the dredge. These cables lead from the buoys downward to ds at the bow and stern of the dredge, projecting below the hull so o leave ample space of free water about 12 feet deep alongside for cing and moving dump scows. The cables run over the sheaves in ends of the spuds and thence up to cable drums operated by the dge machinery. As operations advance the buoys are correspond-ly advanced.

he dredge being in place as determined by the ranges, excavation gins. The dredge makes a cut about 30 feet wide beginning at the e-side line of the proposed trench. This cut is carried to the greatest pth practicable, which is usually within a few feet of rock bottom. is is practicable for the reason that the clay bottom holds a remark-y steep slope, as shown in the typical cross sections of excavated nch accompanying this report. The side cut is excavated to a length from one to several hundred feet, depending upon the distance that be traversed without shifting the anchorage buoys. The dredge hen set back on the initial point and excavates a second cut, which lens the trench to about 60 feet at the bottom. A third cut is then de, further widening the trench to the designated harbor-side line. three cuts thus secure a trench about 90 feet wide at the top. The dge then retraverses the area, and as nearly as practicable cleans the trench to bed rock 50 feet wide.

ack filling the trench with gravel follows the excavation as closely practicable. This is done by dumping in the material from dump ws until the filling reaches the level of the lake bottom or the pre-bed grade. The gravel filling being dropped through 30 and more of water, it spreads out over the trench and deposits without form-lumps and hollows.

he condition of the trench during the progress of excavation and r it is completed, and the condition of the back filling while in gress and when completed, is closely determined by soundings taken a the sounding scow on cross sections 10 feet apart. These cross ions are plotted as fast as the soundings are taken and furnish a able record of the condition of the trench at all times.

TIMBER CRIB BREAKWATER CONSTRUCTION.

Designs.—The crib work is the same in general design as that heretofore used on Buffalo breakwater construction, but several changes have been made in details. The most important of these changes are:

IN CRIBS.

(1) The addition of corner posts and side posts screw-bolted to the crib walls and cross ties. These posts do not extend up into the superstructure but to the top of the cribs only, and are designed principally to strengthen the cribs below water level anticipatory to placing concrete superstructure upon them in the future. The cribs are designed to be 60 feet long and posts are set in each corner of the cribs and 2 at equal spaces along the lake and harbor walls, making 8 posts in each crib.

(2) The grillage planking is confined to the middle third of the crib, leaving ample space for stone filling to run out under the crib walls and support them in case of undermining.

(3) Button-head driftbolts are used throughout in place of headless bolts for bolting timbers above the grillage bottoms.

(4) Longitudinals and alternate cross ties are made up of three pieces of timber overlapping each other, and securely bolted, in order to avoid using an unnecessary number of sticks of timber 36 feet long, and to secure a diversified bill of timber.

IN SUPERSTRUCTURE.

(1) The superstructure in former construction was built 8 feet high and 36 feet wide, surmounted on the lake side by a parapet 4 feet high and 12 feet wide. In order to distribute the weight of stone filling more evenly the superstructure is designed in three "benches," the first 6 feet high and 12 feet wide, the second 4 feet high and 12 feet wide, and the third, or parapet, 2 feet high and 12 feet wide. The banquet is thus lowered 2 feet, which reduces the liability of the guards of vessels moored to the breakwater "hanging" on the breakwater wall, while the height of the structure above water on the lake side remains as heretofore—12 feet.

(2) The deck plank is laid lengthwise with the breakwater structure, instead of crosswise, with walings along all edges, in order to avoid the liability of mooring lines catching in the cracks between planks and wrenching them off.

(3) Iron mooring posts and cleats are used instead of mooring rings, which are inconvenient for securing heavy lines. The posts and cleats are set alternately along the banquet about 100 feet apart. The posts are designed for use when the cleats may have become covered with ice and thus rendered unserviceable.

CONSTRUCTION.

The methods of construction employed are those generally practiced on the lakes. The cribs are built at a construction yard established by the contractor at the Tifft Farm docks, where timber and supplies can be delivered by vessel and by rail. The grillage bottoms for the cribs are built complete on ways and then launched. The required courses of timber are then added. The timber is handled by derricks.

The cribs are towed to the site of the breakwater by a tug, a distance f about 9 miles, and sunk, one at a time, in juxtaposition, on the stone ıundation previously laid and leveled to the proper grade upon the rench filling. While being sunk the crib is held in contact with the one ext preceding it by crossed cables kept taut with turn-buckles. The inking is done by loading stone on a temporary deck laid on the crib. Vhen the crib has been sunk to 6 or 8 inches above mean water level, tone is thrown into the crib along the sides in order to prevent further inking, and the crib is then filled with stone as rapidly as possible. All crib stone is thrown in by hand from scows or canal boats. Two reeks are prescribed for allowing the cribs to settle, and they are then eveled up by adding timber to the side walls or adzing them down, as equired.

The superstructure is then built up continuously over the cribs, the tone filling being added as the work advances, and finally covered rith the deck.

Experience has proved that the finished work will settle, due to the ncreased load imposed upon the cribs by the superstructure. For this eason the cribs are set 6 to 8 inches above grade originally. A part, r sometimes all, of this allowance is taken up by the settlement of he crib alone, but in any event the work is kept at least 4 inches above rade until finished. This method results in securing a straight and early level structure at the prescribed grade after it has fully settled.

The structure is further protected from undermining by the wash of aves on the lake side by a riprap of stone 4 feet high above the lake ottom.

ADMINISTRATION AND REGULATIONS.

Operations on all parts of the breakwater construction are under ıe immediate supervision of an assistant engineer, who regulates the ıethods of operations practiced by the contractor so as to secure the pecified results, and who has general charge of the inspection and ecords of the work and is responsible for the official reports thereof.

On the rubble-mound construction the placement and measurement f materials are inspected and determined by a chief inspector, assisted y two or more inspectors as required.

The trench operations are inspected by one inspector quartered on ıe dredge. The timber-crib breakwater construction, including the onstruction of the stone foundation on the trench filling, is inspected y one inspector, and the construction of the timber cribs at the contractor's yard is inspected by one inspector.

There is also an inspector stationed at the contractor's quarries at Windmill Point, who inspects and measures the several kinds of stone, ınd when required inspectors are employed to inspect the loading and ıuality of stone from other sources of supply and the loading and ıuality of gravel.

The condition and requirements of all parts of the contractors' work ınder water are determined by soundings taken from the sounding ıcow. These sounding operations are constantly going on during avorable weather. The sounding operations are under the supervision f an inspector, who directs the work and records and plots the soundngs as fast as made. A leadsman makes the soundings and several aborers from the contractors' force assist in placing and moving the ıcow from position to position.

The inspection steamer *Gen. John M. Wilson* is employed the greater ıart of the time in the inspection of this work.

To provide shelter and mooring facilities for the contractors' scows and other floating plant 1,200 feet of the south end of the old breakwater has been reserved for the exclusive use of the contractors, and a sign forbidding other vessels to encroach upon this territory has been posted on the breakwater. In order to prevent serious chafing and damage to the timber-crib work of the breakwater, the contractors were required to drive piles about 15 feet out from the harbor face and moor all vessels to these piles. A house boat, containing a dining room, is moored permanently to the breakwater, and meals are there furnished to inspectors and contractors' employees. The house boat also serves as general headquarters, and is connected by telephone with the telephone system of Buffalo, including the contractors' and United States engineer offices, the construction yard, and quarries.

During the years that the breakwater will be under construction vessels attempting to navigate in its vicinity will be liable to serious damage by striking the submerged parts of the structures. The following notice to mariners has therefore been issued:

By direction of the Secretary of War, all persons are hereby warned that it is dangerous to navigate the waters of the east end of Lake Erie between the southern end of the present Buffalo breakwater and Stony Point, where the new breakwater is now under construction, and all persons so navigating do so at their own risk.

And, further, all persons are warned that the operations of the Government contractors engaged in the work of extending the breakwater must not be interfered with.

THOMAS W. SYMONS,
Major, Corps of Engineers, in Charge of River and Harbor Works.

BUFFALO, N. Y., *April 28, 1898.*

QUARRY METHODS AND PLANT.

The quarries of the contractors, from which the large rubble and capping stone used in the breakwater extension is obtained, are located at Windmill Point, Bertie Township, Ontario, Canada. Windmill Point is on the north side of Lake Erie, about 5 miles northwest from Buffalo.

The contractors own a tract of land of about 80 acres, upon which the quarry is located, the land bordering on and lying south of the Grand Trunk Railroad. The quarry is situated between this railroad and the shore of Lake Erie. The contractors' property does not quite extend to the water front, and in order to reach the latter they have the right of way 20 feet wide over the intervening property.

The land upon which the quarry is located is approximately level, the stone being quarried from below the surface of the ground. The overlying earth to the rock is from 2 to 5 feet in depth.

The quarry was opened by removing this earth for a length of about 900 feet and a width of about 50 feet. This stripping was not in a straight line, but was made in two sections, the longer about 600 feet long and the shorter about 300 feet long, the angle at the intersection of the sections being about 30 degrees.

The direction of the longer section is approximately east and west.

After the stripping was completed tracks were laid along the south edge of the same and a line of derricks erected between the tracks and the stripping. The rock was then blasted out by heavy charges of dynamite, ranging in power from 30 to 50 degrees. Soon after blasting operations were begun it was found that the strata at the eastern end of the quarry were thicker than at the western end, the layers running from 2 to 5½ feet in thickness. Blasting operations were therefore confined to the western end, the excavated material being used for

ıbble, while that at the eastern end was reserved for revetment and ıpping stone. For drilling the holes Ingersoll-Sargeant steam drills re used, the size of the holes being 2¼ inches at the start and reduced › 2 inches at the bottom. As the object was to get depth, heavy ıarges of dynamite were used, which greatly shattered the rock.

A depth of 30 feet below the surface of the ground was aimed at, but ıis depth was only reached at a few points at the end of the working ɔason of 1897.

The capping stone is quarried in large blocks with one dimension, pproximately 6 feet, holes starting at 1½ inches and ending at 1¼ ıches being drilled at intervals. These holes are then enlarged at ıe top by a rimmer and charged and exploded by black powder.

To transport the stone the contractors have built a 3-foot gauge ıilroad from the quarry to the loading dock on Lake Erie. The load- ıg dock is about one-fourth of a mile long. The inner end is built f isolated timber cribs filled with stone, the intervening spaces being ridged by pine stringers. The outer end of the dock is a continuous rib structure filled with stone, and upon this the loading appliances re located.

At the opening of the working season of 1898 operations at the quarry ere diligently prosecuted, and at this writing the quarry has reached depth of 30 feet for a length of about 600 feet. A double track has een laid along the south face of the quarry at a height of 6 feet above he bottom, the foundation of the tracks being the débris from the uarry operations. The derricks which formerly stood at the left of the uarry have been removed to the bottom. Seven derricks, placed bout 80 feet apart, have been put in operation in that part of the quarry rom which the rubblestone is obtained. An inclined plane has also een built and is used for drawing the loaded cars out of the quarry. ıs only a limited amount of capping stone has been quarried, that part f the quarry has not yet reached the proposed depth, and operations re confined close to the surface.

To handle the capping stone 5 derricks are in operation.

The contractors have 14 Ingersoll-Sargeant steam drills in operation; f these 6 are large, 3 medium, and 5 pony drills. To furnish the nec- ɔssary steam there are 4 boilers, each 50 horsepower. Water is supplied ɔy 2 Worthington pumps; one 3 inches and one 2 inches discharge. There are also 2 hoisting engines with upright boilers and 5 skeleton ıoisting engines.

The railroad equipment consists of two 11-ton locomotives with cylin- ders 8 by 14 inches, 5 dump cars, and 67 flat cars; also 70 skip boxes. There is also a 25-ton track scale.

The distance from the work end of the quarry to the lake end of the loading dock is about 1 mile; much of this track is double. There are also tracks for carrying away the stripped material, track to engine ıouses, sidings, etc.; so altogether the contractors have over 3 miles of ɔack in use.

The plant at the loading dock consists of 2 stiff-leg derricks, having ı capacity of 20 tons each, 2 hoisting engines, and 2 loading chutes.

There are quarters for workmen in two buildings, 20 by 112 feet in ize. There is also a boarding house 20 by 60 feet in size, dwelling ıouse, office and store room, blacksmith shop with four fires, etc.

CONTRACTORS' WORKING FORCES.

The following statement of the forces employed on the several parts ɔf the work during June, 1898, shows these forces when the contractors' ɔorking plant is in full operation.

At quarries.—Ten foremen, 1 timekeeper, 2 engine drivers, 8 hoist engineers, 12 drillers, 12 drill helpers, 6 carpenters, 5 firemen, 4 blacksmith helpers, 2 watchmen, 3 teams, 165 laborers, and 5 water boys.

At Lockport.—Two foremen, 2 hoist engineers, 1 fireman, 2 water boys and 86 laborers.

Niagara River.—One dredge with full crew, 4 scows and scow men, 1 large tug and crew.

Wrecked shore arm.—One dredge and crew, 2 scows and scow men, 1 tug and crew.

On rubble-mound construction.—One superintendent, 1 timekeeper, 3 to 5 foremen, 1 to 2 derrick scows, 2 to 4 hoist engineers, 3 yawls, 9 boatmen, 26 laborers, 1 cook.

On trench excavation.—One large dredge and crew, 2 dump scows and scow men, 2 tugs and crews.

On timber crib building at yard.—Two foremen, 18 carpenters, 34 laborers, 3 teams.

On timber breakwater construction.—Three foremen, 1 to 2 hoist engineers, 4 to 6 carpenters, 50 laborers.

ACCIDENTS.

Four serious accidents, three of which caused loss of life, occurred during the fiscal year 1898.

On August 19, 1897, the scow *Rory O'Moore* while being towed up Niagara River loaded with gravel sprung a leak and sunk. The scow man was drawn into the open hatchway by suction as the scow was sinking and was drowned.

On September 28, 1897, the officer in charge and Assistant Engineer Quintus were returning from an inspection trip on the chartered steam yacht *Glance.* The steamer *Gazelle* overtook, ran down, and sunk the yacht in the harbor entrance channel. The officer in charge and captain of the yacht were rescued from the water by the life-saving crew. The engineer of the yacht was drowned. The assistant engineer climbed onto the *Gazelle.*

In September, the scow *Rory O'Moore,* lying at the breakwater, was run into and sunk by the steamer *Maine.*

On December 5, 1897, a westerly gale tore the scows *Rory O'Moore* and *Kathleen Bawn* from their moorings at the breakwater and drove them high and dry on the beach. They were floated with much difficulty in the spring.

On April 6, 1898, the dredge *Brian Boru* foundered in 16 feet of water while being towed to shelter during a storm, and three of the crew were drowned. The dredge was raised with difficulty in May, 1898, and was refitted and ready for work June 1, 1898.

OCCUPATION OF THE UNITED STATES NORTH PIER BY THE DELAWARE, LACKAWANNA AND WESTERN RAILROAD COMPANY.

This pier is the only one of the Government harbor works permanently occupied by corporations or private parties.

The occupancy of the pier began in 1878. A history of this occupancy and copies of official documents relating thereto are given in the Report of the Chief of Engineers, United States Army, for 1889, pages 2373–2383. A revocable license (printed in above-mentioned report) issued by the Secretary of War January 4, 1889, was revoked by the Secretary of War February 20, 1891. The following is a copy:

NOTICE OF REVOCATION OF LICENSE.

To the Delaware, Lackawanna and Western Railroad Company:

Take notice that—

Whereas a license was granted to the Delaware, Lackawanna and Western Railroad Company by the Secretary of War, under date of January 4, 1889, and was accepted by said company under date of January 5, 1889, authorizing it to reconstruct the pier known as the North Pier in the Harbor of Buffalo, N. Y., built by the United States in 1819, said license being revocable at the will of the Secretary of War, and it having been made to appear to the satisfaction of the Secretary of War that the interests of the United States require that the said license should be revoked,

Now, therefore, this is to certify that the Secretary of War has this day revoked this license.

Witness my hand this 20th day of February, 1891.

REDFIELD PROCTOR,
Secretary of War.

In his annual report on the improvement of Buffalo Harbor, New York, for 1891, Maj. Amos Stickney, Corps of Engineers, states:

It is understood that the Department of Justice will take the necessary steps to protect the interests of the Government in this matter.

So far as known, nothing has been done by the Department of Justice, and no further steps were taken by the War Department until 1897.

On November 11, 1897, the following letter was sent to the Chief of Engineers:

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., November 11, 1897.

GENERAL: I have the honor to state that a sense of duty compels me to invite attention to the condition of affairs at the entrance to Buffalo Harbor.

There is submitted herewith a chart of Buffalo Harbor and a sketch map of the entrance thereto on an enlarged scale.

The vast commercial business of Buffalo is practically all transacted at the wharves, elevators, basins, etc., of Buffalo Creek and the Blackwell Ship Canal.

The throat through which all this commerce flows is the narrow channel, 200 feet wide, between the Government piers on the north and south sides of the entrance, as shown. Through this entrance great numbers of vessels of all kinds are ever passing—great lake steam freighters, towed barges, passenger vessels for upper lake ports, excursion and local passenger vessels, tugs and canal boats in great numbers, scows loaded with dredgings and other materials, supply boats going to vessels moored to the breakwater or anchored in the outer harbor, and other small vessels in great variety and number. It is also necessary at times to occupy a portion of the waterway by dredges, scows, etc., engaged in deepening the channel.

This width of 200 feet between the piers, adopted many years ago, was undoubtedly fixed upon as the minimum width suited for the harbor entrance. Since its adoption the Blackwell Ship Canal has been built and the commerce of Buffalo has increased at an exceedingly rapid rate.

This commerce is still increasing and the size of vessels engaged in it is increasing, and it is submitted that this narrow entrance of 200 feet should be maintained at its full width and completely unobstructed for the general purposes of commerce. Unless it is so maintained very serious accidents are liable to occur and reasonable and just cause for complaints would exist.

As a matter of fact, this entrance channel, while maintained physically at nearly its full width of 200 feet, is so constantly obstructed by ships moored along the north pier that its navigable width for general purposes and general use is materially curtailed.

The north pier is occupied by the coal trestle of the Delaware, Lackawanna and Western Railroad Company, and there is scarcely an hour during the active season of lake navigation that there is not a vessel or vessels moored to the pier, loading with coal or waiting before or after loading. A large coal carrier occupies about 50 feet, or one-fourth of the entrance channel. In many instances a fuel scow 30 to 40 feet wide will lay alongside such a vessel fueling her and occupying 30 to 40 feet more of the channel way and reducing the navigable width to about 120 feet. In many instances two large vessels lie side by side moored to this north pier and taking up nearly one-half of the available width of the channel, and not infrequently three vessels lie side by side in this narrow harbor entrance, taking up considerably more than half the entrance channel.

I recently had an experience which brought to mind vividly the wrong to the sea-going public of allowing this obstructive mooring to the north pier to continue. On

the 28th day of September last I was coming into the harbor from a tour of inspection on the chartered steamer *Glance*. At the same time there was entering a tug towing a barge of stone and an excursion steamer, the *Gazelle*. Moored to the north pier was the large steamship *Niagara* loading with anthracite coal, and alongside her was a fuel scow supplying her with steam coal. In trying to pass the tug and scow and the *Glance* on one side and avoid the vessels moored to the north pier on the other side, the *Gazelle* ran into the *Glance*, overturning her. The engineer of the *Glance* was drowned and the others on board, including myself, had an exceedingly narrow escape from drowning.

On October 23, on coming into the harbor from a tour of inspection, I found three ships lying abreast moored to the north pier and taking up more than half the entrance channel.

In some cases those vessels moored at the north pier extend far out beyond its outer end, materially interfering with the entrance into the Erie Basin, Coit Slip, etc.

These vessels so moored to the north pier form veritable obstructions to the navigable capacity of the entrance channel, which should not be permitted, and it is respectfully submitted that the general interests of commerce and navigation require that the mooring of vessels to the north pier in the entrance channel of Buffalo Harbor should be absolutely prohibited. Such prohibition would interfere with the coal-shipping business of the Delaware, Lackawanna and Western Railroad Company as at present conducted from the north pier, but this fact should not be given great consideration as the company is occupying this pier practically only as a squatter upon the property of the United States.

For a history of the occupation of the north pier by the Delaware, Lackawanna and Western Railroad Company attention is respectfully invited to the Report of the Chief of Engineers for 1889, page 2373 et seq. On page 2883 of the Report of the Chief of Engineers for 1891 appears this statement:

"The occupation of the north pier by the Delaware, Lackawanna and Western Railroad Company still continues, notwithstanding the fact that the license for such occupation was revoked by the Secretary of War on February 20, 1891. It is understood that the Department of Justice will take the necessary steps to protect the interests of the Government in this matter."

As far as known to this office, nothing has been done further to protect or enforce the rights of the United States in the property in question, and the company has gone on with its unauthorized occupancy of Government property, and in connection therewith has gone on obstructing the entrance to Buffalo Harbor by making the north pier a mooring and loading place for vessels engaged in the coal-carrying business, a use for which it certainly was never intended. The possibility of the Delaware, Lackawanna and Western Railroad Company obtaining title to the north pier property by adverse possession demands that steps be taken to protect the interests of the United States.

I deem it my duty to urge that immediate and energetic steps be taken to determine the rights of the United States and of the Delaware, Lackawanna and Western Railroad Company in the north pier, but above all and before all, that the necessary steps be taken and orders be issued to prohibit, after the close of the present season of navigation, any mooring of vessels to the north pier or the stoppage of vessels in the entrance channels between the Government piers, or between the north pier and the Erie Basin breakwater for any purpose whatever, unless connected with the work of improving the channel or harbor.

In this connection the following statistics of the commerce of Buffalo for the year 1896 are given:

Arrivals and departures by lake and river	10,446
Arrivals and departures by canal	11,576
Total	22,022

Practically all of the lake and river movement passes through the narrow entrance channel, and so does about 75 per cent of the canal movement.

Besides the above there is a very large number of passages by tugs, scows, supply boats, canal boats, etc., which is in addition thereto.

The tonnage of vessels arriving and departing by lake and river during the season of 1896 was 11,053,206 tons, and by canal 1,570,743 tons, or 12,623,949 tons altogether.

It is also deemed proper to show the relation which exists between the commerce and width between entrance piers of Buffalo and other Lake Erie ports having entrance piers.

The commerce of the port of Cleveland is about one-half that of Buffalo. The width between the entrance piers at Cleveland was 250 feet at their outer ends, narrowing to 130 feet at the railroad bridge. This is now being increased throughout by the construction of a new west pier, making the entrance 325 feet wide.

The commerce of Ashtabula is about one-third that of Buffalo in tonnage and

ıly about one-fifth in number of arrivals and departures. The width between the ıtrance piers at Ashtabula is 213 feet.
The commerce of Erie is about one-third that of Buffalo, and the width between ı entrance piers is 350 feet.
The commerce of Fairport is about one-fifth that of Buffalo, and the width between e entrance piers is 185 feet.
The commerce of Conneaut is about one-eighth that of Buffalo, and the width tween the entrance piers is 200 feet.
The commerce of Lorain is about one-twentieth that of Buffalo, and the width tween its entrance piers is 206 feet.
The commerce of Monroe is about one-ninetieth that of Buffalo, and the width tween its entrance piers is 210 feet.
The following table gives the figures upon which these generalizations are based. The statistics are from the annual report of the engineer officers in charge of the rious harbors.

ARRIVALS AND DEPARTURES.

Port.	1895.		1896.		Width between entrance piers.
	Vessels.	Tonnage.	Vessels.	Tonnage.	
ffalo	a 9,975 b 9,092	a 9,612,423 b 1,181,960	a 10,446 b 11,576	a 11,053,206 b 1,570,743	200 feet.
	19,067	10,794,383	22,022	12,623,949	
veland	7,474	5,649,537	7,203	5,991,656	130 to 250 feet, being increased to 325 feet throughout.
htabula	3,819	4,410,984	3,307	3,994,198	213 feet.
le	2,936	3,323,572	3,100	3,634,842	350 feet.
nneaut	822	927,833	1,148	1,519,173	200 feet.
irport	1,332	2,184,962	1,140	1,698,809	185 feet.
rain	1,026	617,126	498	358,782	206 feet.
onroe	716	122,588	.....	.....	210 feet.

a Lake. b Canal.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

To this the following reply was received:

OFFICE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 17, 1898.

MAJOR: Your letter of November 11, 1897, calling attention to the serious condition affairs at the entrance to Buffalo Harbor, arising from the obstructive mooring of ssels to the north pier, and asking that steps be taken to determine the respective ghts of the United States and the Delaware and Lackawanna Railroad Company the north pier, has been submitted to the Secretary of War by indorsement, of hich the following is a copy:

["First indorsement.]

"OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
"*January 5, 1898.*

"Respectfully submitted to the Secretary of War.
"Under an act of the legislature of the State of New York, passed in 1819, certain tizens of Buffalo undertook the improvement of that harbor and built what is ıown as the 'north pier,' in the water below low-water mark, upon land the title which was in the State of New York. In 1826 this pier passed under the control the United States and was reconstructed in a more substantial manner upon ractically the same lines as the old pier. For fifty-two years, or until 1878, the nited States had actual, uninterrupted physical possession of the pier, claiming itle thereto, and during that time it expended about $400,000 on the pier. In 1878 he Delaware, Lackawanna and Western Railroad Company, claiming title to the and, became a squatter on this pier, and since that time there has been a contro- ersy between the Government and the company in regard to possession of the pier, ut by various compromises and arrangements with the War Department the com-

pany has retained possession. A brief of the action taken by the War Department in the matter will be seen by reference to the accompanying paper marked 'A.'

"The Department of Justice has expressed the opinion that the railroad company has no claim either legal or equitable to the land on which the pier rests, and never had any; and that the title of the United States rests upon its possession of the pier for fifty-two years and its maintenance of the pier during that time.

"The occupancy of the pier by the railroad company has been a source of great injury to the navigation interests of Buffalo Harbor, and frequent and numerous complaints have been made by steamboat companies and other commercial organizations. In the within letter Major Symons states clearly the present condition of affairs, the great injury that is being done to the shipping of Buffalo, and the necessity that some step be taken to establish the rights of the Government and to protect the interests of the public.

"To my mind the whole question is one of title, and the proper steps should be taken to determine this question. Efforts have been made in the direction repeatedly, but before anything definite had been decided upon the matter has been postponed by some arrangement with the railroad company whose sole object seems to be to retain control and possession of the pier for its own uses. A line of action was suggested by the United States attorney for the Buffalo district in 1891 (see his letter of October 19, 1891, herewith), which was concurred in by the Attorney-General, but before it was carried out another compromise was arranged. Whether such action would be the proper one at this time I am unable to say, and therefore recommend, as a preliminary, that the Attorney-General be requested to give the subject careful consideration and to advise the War Department of the proper course to pursue to test and settle the respective rights of the United States Government and the Delaware, Lackawanna, and Western Railroad Company to the possession of the North Pier in Buffalo Harbor.

"Various reports and documents giving a full history of the case are herewith.

"JOHN M. WILSON,
"*Brig. Gen., Chief of Engineers, U. S. Army.*

"This office has been advised by the War Department that the papers have been transmitted to the Attorney-General with request for action as recommended by the Chief of Engineers in the aforesaid indorsement.

"By command of Brig. Gen. Wilson:

"Very respectfully, your obedient servant,

"A. MACKENZIE,
"*Lieut. Col., Corps of Engineers.*"

Maj. THOMAS W. SYMONS,
Corps of Engineers.

The following reply was made to the above:

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., January 24, 1898.

GENERAL: I have the honor to acknowledge receipt of your letter of January 17, 1898 (23468), containing copy of your indorsement on my letter of November 11, 1897, concerning the occupation of the north pier at Buffalo by the Delaware, Lackawanna and Western Railroad Company.

It is very much to be hoped that the old and vexed question regarding the ownership of this north pier may now be followed up until it is decided. But I beg to suggest that there is something more in the question than the mere fact of ownership of the ground on which the north pier stands. This refers to what rights in the channel are carried by this ownership. If the final result of the trial of the case should be to confirm the claims of the Delaware, Lackawanna and Western Railroad Company in the ownership of the pier, would this carry with it commercial, wharfing, riparian rights on the channel front of this property with the right to block the channel by mooring ships therein? This is a more important matter than the ownership of the property itself.

I can not believe that it would carry such rights to the detriment of the entire commerce of Buffalo. It seems to me that this channel comes under section 4 of the river and harbor act of August 17, 1894, and that the Secretary of War has the right to prescribe the use, administration, and navigation of it.

I am of the opinion that the Secretary of War has full and complete right to regulate the use of the channel at the present time and to prevent its obstruction, regardless of whether the Delaware, Lackawanna and Western Railroad Company make good their claim to ownership of the pier or not. And as there must surely be a long time, perhaps years, elapse before the question of ownership is finally settled, owing to the law's delays, I would suggest and recommend that all the power of the War

Department be immediately used to prevent the further obstruction of the channel by mooring vessels to the north pier.

Very respectfully, your obedient servant,

THOMAS W. SYMONS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

This was forwarded to the Secretary of War with the following indorsement by the Chief of Engineers:

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
February 16, 1898.

The vast commercial business of Buffalo Harbor is practically all transacted at the wharves, elevators, and basins of Buffalo Creek and the Blackwell Ship Canal. The throat through which all this commerce flows is the narrow channel, 200 feet wide, between the piers on the north and south of the entrance. Through this channel great numbers of vessels of all kinds are ever passing—Great Lake steam freighters, towed barges, passenger vessels, tugs, and canal boats in great numbers, scows loaded with dredgings and other materials, supply boats going to vessels moored to the breakwater or anchored in the outer harbor, and other small vessels in great variety and number. It is also necessary at times to occupy a portion of the waterway by dredges and scows engaged in deepening the channel. The commerce is still increasing and the size of vessels engaged in it is increasing, and this narrow entrance of 200 feet should be maintained at its full width, otherwise very serious accidents are liable to occur and the movement of vessels to be seriously impeded.

As a matter of fact, this entrance channel, while maintained physically at nearly its full width of 200 feet, is so constantly obstructed by ships moored along the north pier that its navigable width for general purposes and general use is materially curtailed. The officer in charge of the improvement of the harbor reports that there is scarcely an hour during the active season of navigation when there is not a vessel or vessels moored to the north pier, loading with coal or waiting before or after loading. A large coal carrier occupies about 50 feet, or one-fourth of the entrance channel. In many instances a fuel scow 30 to 40 feet wide will lay alongside such a vessel fueling her and occupying 30 to 40 feet more of the channel way and reducing the navigable width to about 120 feet. Sometimes two large vessels lie side by side moored to this north pier and taking up nearly one-half of the available width of the channel, and not infrequently three such vessels lie side by side, taking up considerably more than half the channel. In some cases these vessels moored at the north pier extend far out beyond its outer end, materially interfering with the entrance into the Erie Basin and Coit Slip.

The north pier, originally built by citizens of Buffalo, passed under the control of the United States in 1826, when it was reconstructed in a more substantial manner. For fifty-two years, or until 1878, the United States had actual physical possession of the pier, claiming title thereto, and expending large sums of money for its maintenance. In 1878 the Delaware, Lackawanna and Western Railroad Company became a squatter on the pier, and, though there has been since that time a controversy between the Government and the company in regard to possession, the company has by various compromises and arrangements with the War Department retained possession. The occupancy of the pier by the railroad company has been a source of great injury to the navigation interests and frequent and numerous complaints have been made by steamboat companies and other commercial organizations. The Secretary of War has recently requested the Attorney-General to advise him of the proper course to pursue to test and settle the respective rights of the United States Government and the railroad company to the possession of the pier.

In the meantime the practice of mooring vessels to the pier, as above described, forms veritable obstructions to the navigable capacity of the entrance channel, which it is believed the Secretary of War can prohibit by prescribing suitable regulations under the provisions of section 4 of the river and harbor act of August 18, 1894.

A draft of regulations for the use, administration, and navigation of the entrance channel, prepared by Major Symons, is herewith submitted, and I recommend their favorable consideration by the Secretary of War.

The channel in question is similar to the channels through Maumee Bay and St. Clair Flats, for which regulations have been prescribed by the Department.

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Subsequent indorsements by the Secretary of War show that it was his decision that vessels might lie at the north pier, but should be prohibited from anchoring in the channel or lying at the north pier abreast of one another. The orders of the Secretary in the matter have not yet been published, but the Delaware, Lackawanna and Western Railroad Company have put up large signs prohibiting vessels mooring abreast and have adopted stringent wharf regulations in the endeavor to prevent it.

Nothing has been heard of any action of the Department of Justice looking to the legal determination of the rights of the United States in the matter.

CONTRACTS.

The only contracts in force or made during the year are those mentioned on page 3113 of the last Annual Report of the Chief of Engineers, except a supplemental contract entered into under date of April 26, 1898, with the regular contractors, Hughes Bros. & Bangs, by which they are allowed to increase the quantity of stone to be brought from Canada by submitting to a reduction of 5 cents per ton on all excess stone so brought.

ERIE CANAL.

The Erie Canal is a very important feature in the commerce of Buffalo, and it is deemed proper to mention it in connection with the works of harbor improvement undertaken by the General Government.

During the year 1897 the business of the canal reached a very low ebb, only amounting to five-sevenths of that in 1896. The State of New York in 1895 authorized the expenditure of $9,000,000 for the improvement of this canal, and the work has been under way ever since.

Last winter it was ascertained that the $9,000,000 would not be nearly sufficient to complete the work laid out, which work was, in general, to deepen the canal to 8 feet and to provide locks which would enable boats to lock through in pairs.

A great deal of dissatisfaction and comment was aroused by the condition of affairs, and the legislature passed a law authorizing the appointment of a commission to investigate the expenditure of the $9,000,000 and the methods of conducting the work. This committee, which is headed by Mr. George Clinton, a grandson of Governor De Witt Clinton, who originally built the canal, has not yet completed its labors and made its report.

There can be no question as to the great desirability of the completion of the work on this canal as outlined in the general plan, and it is very much to be hoped that it can be carried into effect for the general benefit of the commerce on the lakes and the people of the East and of the West. I am, however, convinced that in the future a very much more radical improvement than that undertaken by the State is justifiable and will be demanded in the interests of commerce, and I can see no reason why this very important waterway connecting the Great Lake region with the chief commercial and manufacturing center of the country should not receive the fostering care of the General Government.

SEA-WALL STRIP.

During the years between 1830 and 1836 a masonry sea wall was built by the United States Government, running southerly from the inner end of the United States south pier along the lake front of the city of Buf-

outh and west of Buffalo Creek. A plan and cross section all is given on page 136 of the Annual Report of the Chief s for 1867.

; of the sea wall was to protect the lake front of the city of nst the storms on Lake Erie. In 1867 this sea wall had tal completed length of 5,400 feet. No work was done on after 1867, for the reason that the outer breakwater was 69 and this structure rendered the sea wall unnecessary

, 1864, an act was passed by the legislature of the State of ntitled "An act authorizing the city of Buffalo to lay out a id for the purpose of maintaining and protecting a sea wall er along the shore or margin of Lake Erie."

4, 1870, another act was passed by the legislature of the w York entitled "An act authorizing the common council f Buffalo to lay out a public ground for the purpose of pro- ity of Buffalo and its harbor from the encroachment of Lake

provisions of these acts lands now known as the "sea-wall laid out and acquired by the city of Buffalo. This sea- 130 feet wide and commences at a point near the entrance extends southerly 7,050 feet.

was made in the act of 1864 "to grant to the United States right to occupy and possess said land, or any part thereof, round for the purpose of erecting and maintaining thereon breakwater." Provision was further made that "common direct deed or deeds to be made * * * granting and con- e United States said land, or any part thereof, for the pur- ting and maintaining thereon a sea wall or breakwater."

1870 practically reenacts these provisions, but with the hat "land or lands * * * shall be upon condition to therein that the United States shall maintain and keep in d lands the said sea wall or breakwater." Neither of these as ever complied with. The sea wall, however, occupies a large part of its length and is the property of the United sea wall has not, however, been kept in repair, as no work ie upon it since 1867, as heretofore stated.

ion of the present project for the improvement of Buffalo ch provides for the extension of the United States break- ny Point, will render the entire lake front along the sea- ailable for commercial purposes.

sted condition of commerce at the docks and wharves in k and the City Ship Canal causes a demand for more com- ks, and this demand is emphasized by the increase in the essels. The commercial interests of Buffalo, fully realizing ice of the development of the lake front for better wharf- en well represented in the matter, and the last legislature of New York passed a bill authorizing and permitting the lo to use the sea-wall strip for highway purposes. The the act of the State legislature referred to:

f the State of New York, represented in senate and assembly, do enact

t shall be lawful for the city of Buffalo to use or occupy the lands and ibed as follows, to wit: "A strip or piece of land one hundred and , beginning at the east boundary of land owned by the United States ience along the shore or margin of Lake Erie to the South Channel, asterly boundary of which strip or piece of land is thirty feet distant

at right angles from the hereinafter described line and parallel thereto, and the westerly boundary of which strip or piece of land is one hundred feet distant at right angles from the said line and parallel thereto." The said line is described as follows: "Beginning at a point in the easterly boundary of the lands owned by the United States, on the westerly side of Buffalo Creek, where the easterly side of the cross wall or mole running along the beach crosses said boundary; thence south twenty-two degrees and ten minutes east to the west side of Commercial street extended; thence south twenty-eight degrees and twenty-five minutes east thirteen hundred and twenty-four feet; thence south thirty-two degrees and thirty-five minutes east eleven hundred and twenty-nine feet; thence south twenty-seven degrees and eight minutes east to the northerly line of the South Channel, so called, excepting from said strip or piece of land so much thereof as is embraced in the said land owned by the United States," acquired pursuant to chapter five hundred and forty-seven of the laws of eighteen hundred and sixty-four, entitled "An act to authorize the common council of the city of Buffalo to lay out a public ground for the purpose of maintaining and protecting a sea wall or breakwater along the shore or margin of Lake Erie," for the purpose of a public street or highway under the jurisdiction and control of the common council and department of public works of said city, in accordance with the provisions of chapter one hundred and five of the laws of the year eighteen hundred and ninety-one, and the acts amendatory thereof and supplemental thereto.

SEC. 2. Nothing in this act contained shall be so construed as to ratify, confirm, validate, or legalize any acts or proceedings of the common council or other authorities of said city adopted or enacted prior to the date of the passage of this act, or to ratify, confirm, validate, or legalize any legal or judicial proceedings heretofore had and taken under and in pursuance whereof any person or persons, individual or individuals, corporation or corporations, are in possession of or claim to hold an interest in or title to the lands and premises described in the first section of this act or any part thereof.

SEC. 3. All acts or parts of acts inconsistent with this act are hereby repealed.

SEC. 4. This act shall take effect immediately.

The bill received the approval of the governor of the State and is now a law.

The strip is admirably situated and suited for a highway along the outer harbor, and it is highly gratifying to know that its use as a public highway has been authorized. It still remains for the United States to formally abolish the sea wall as a work of harbor improvement and to provide for its abandonment or disposal.

REMARKS.

The progress of the work on the breakwater extension has not been as rapid as desired by this office or as called for by contract obligations. At the same time it is recognized that in a work of the magnitude of this, with new and hitherto untried features, and with the necessity for making preparations for procuring materials in enormous quantities, much allowance must be made for experiments, for getting suitable plant, opening quarries, etc.

Everything is now in good shape to push operations with all reasonable rapidity, except in the matter of revetment and capping stone. This has been and is yet the weak point in the conduct of the work. The contractors are now changing the method of operating their quarry at Windmill Point by lowering the derricks into the pit and arranging an incline down which to run cars. This it is expected will be completed by July 15, after which it is hoped and expected that revetment and capping stone will come with much greater rapidity.

The contractors are building more deck scows for handling large rubble and revetment and capping stone, and, while the present season will not see as much work done as we hoped, it is believed that matters will be so well in hand for the next and subsequent seasons that the contract will ultimately be completed on time in 1901, and within the limits of the estimate.

The fiscal years ending in 1897 and 1898 must be considered largely

s experimental and preparatory periods, and the next two fiscal years nding in 1899 and 1900 as the seasons of greatest activity, when the ork will progress in all its branches at the maximum rates.

ESTIMATES.

New construction.—On the 1st day of July, 1898, the amount of funds n hand for construction, after deducting indebtedness, was about 273,000. In addition thereto is the amount in the sundry civil bill of uly 1, 1898, $489,746, making a total of $762,746. It is estimated that he breakwater contractors will earn during the fiscal year ending June 0, 1899, the sum of $670,000, and that the engineering and office xpenses connected with the work will be $30,000, making a total of 700,000 to be expended for construction during the year, and leaving n estimated balance on hand for construction, July 1, 1899, of $62,746.

It is further estimated that the amount which will be earned by the ontractors under the continuing contract for the Buffalo Breakwater xtension during the fiscal year ending June 30, 1900, will be $590,000, nd that the necessary engineering and office expenses will be for the ame period $30,000, or $620,000 in all.

Taking the estimated amount on hand July 1, 1899, i. e., $62,746, om this estimated expenditure for the fiscal year ending June 30, 1900, e., $620,000, leaves $557,257, and this is the amount which should be rovided in the next sundry civil bill for the new work authorized by ie act of June 3, 1896.

The estimates of the amounts to be earned by the contractors are ased upon figures made by the contractors themselves, and indicate hat they expect to earn.

Maintenance.—On July 1, 1898, the amount of funds on hand for aintenance was $127,164.36, being the amount of money on hand from ormer appropriations left over at the beginning of the present break- ater-extension operations. It is estimated that it will be necessary o expend for repairs to breakwater and piers during the fiscal year nding June 30, 1899, the sum of $7,000, leaving an estimated balance n hand for maintenance July 1, 1899, of $120,164.36.

During the fiscal year ending June 30, 1900, it will certainly be nec- ssary and expedient to concrete the 1,015 feet of old breakwater herein entioned, and the estimated expenditure for this will be $126,875, and or ordinary repairs to breakwater and piers, $2,000, making $128,875 n all.

If we take from this the estimated amount which will be on hand uly 1, 1899, i. e., $120,164.36, there remains $8,710.64, which is the mount which should be appropriated for maintenance for the fiscal ear ending June 30, 1900.

This estimate for maintenance includes an item of $126,875 for replac- ng the wood and stone superstructure on 1,015 feet of the old break- water with a concrete superstructure. This old portion of the break- water was built in 1873 to 1877, and is in such an unsafe condition that at any time it may be demolished. In 1889 to 1891 the portions on both sides of it received a concrete superstructure, and the only reason that it was left unconcreted at that time was the insecurity of its founda- tion. This foundation has now been secured and the putting on of the concrete superstructure should no longer be delayed.

The section is situated 1,910 to 2,925 feet from the northern end of the breakwater, and if it should be demolished it would very seriously incommode the shipping which makes use of the outer harbor; and if demolished by storms it would in all probability take a large part of

the underlying crib work with it, and thus render the ultimate cost of repairs very much greater.

SUMMARY OF ESTIMATES.

The expenditures for the fiscal year ending June 30, 1900, are estimated as follows:

New construction under continuing contract.

To be earned by contractors on continuing contract for Buffalo breakwater extension	$590,000	
Engineering and office expenses	30,000	
		$620,000

Maintenance.

Repairs to old breakwater and piers	2,000	
Replacing with concrete the 1,015 feet of breakwater	126,875	
		128,875
Total for construction and maintenance		748,875

To offset this there will be on hand, it is estimated, the sum of $182,910.36, leaving $565,964.64 to be provided, divided as follows:

For new construction under continuing contract	$557,254.00
For maintenance	8,710.64

Money statements.

CONSTRUCTION, NEW WORK.

July 1, 1897, balance unexpended		$469,347.86
Amount appropriated by sundry civil act approved July 1, 1898		489,746.00
		959,093.86
June 30, 1898, amount expended during fiscal year		153,457.07
July 1, 1898, balance unexpended		805,636.79
July 1, 1898, outstanding liabilities	$500.00	
July 1, 1898, amount covered by uncompleted continuous contracts	1,637,754.27	
Amount (estimated) required for completion of existing project		*1,229,004.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		620,000.00
		†557,254.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

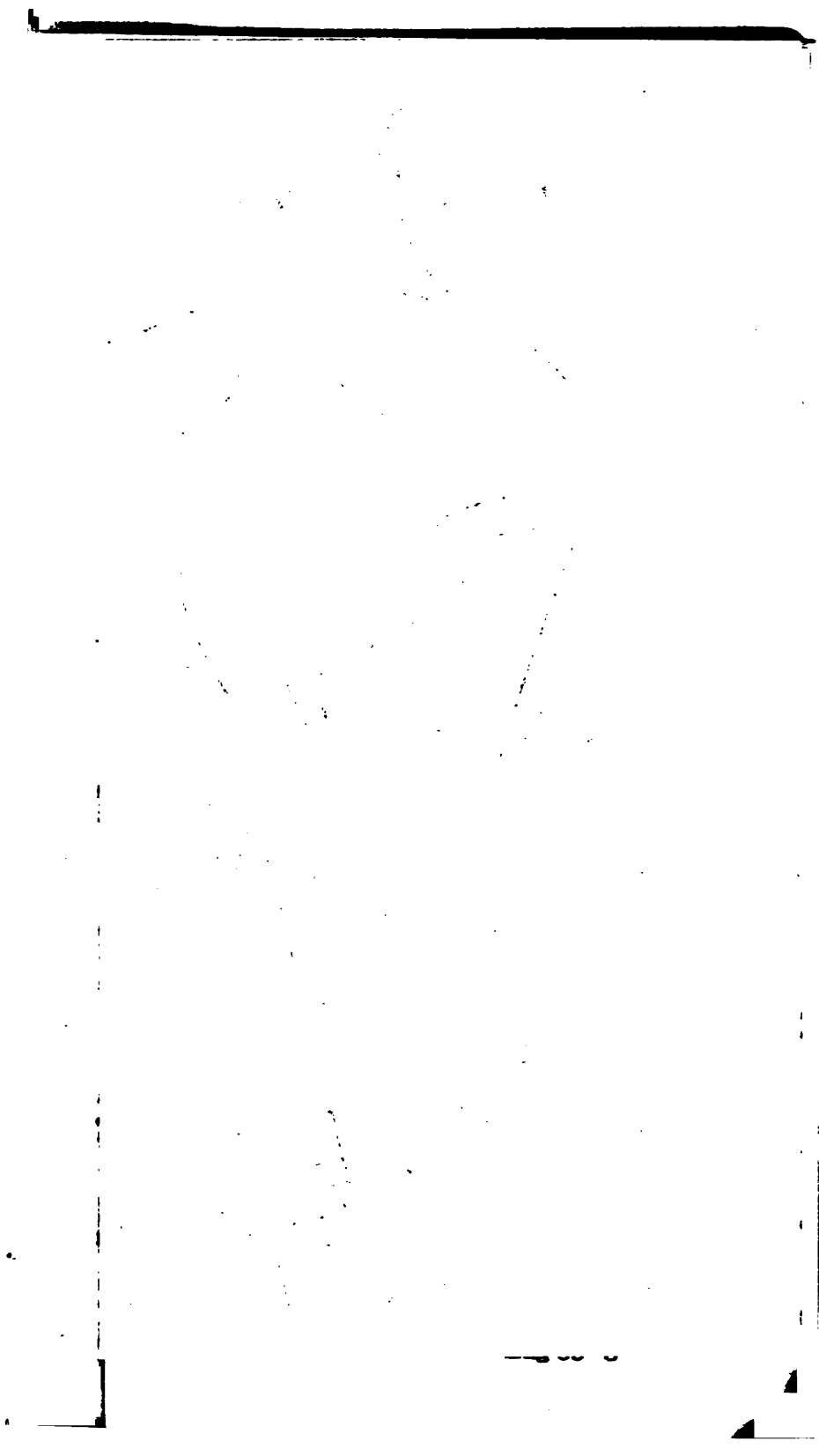
MAINTENANCE.

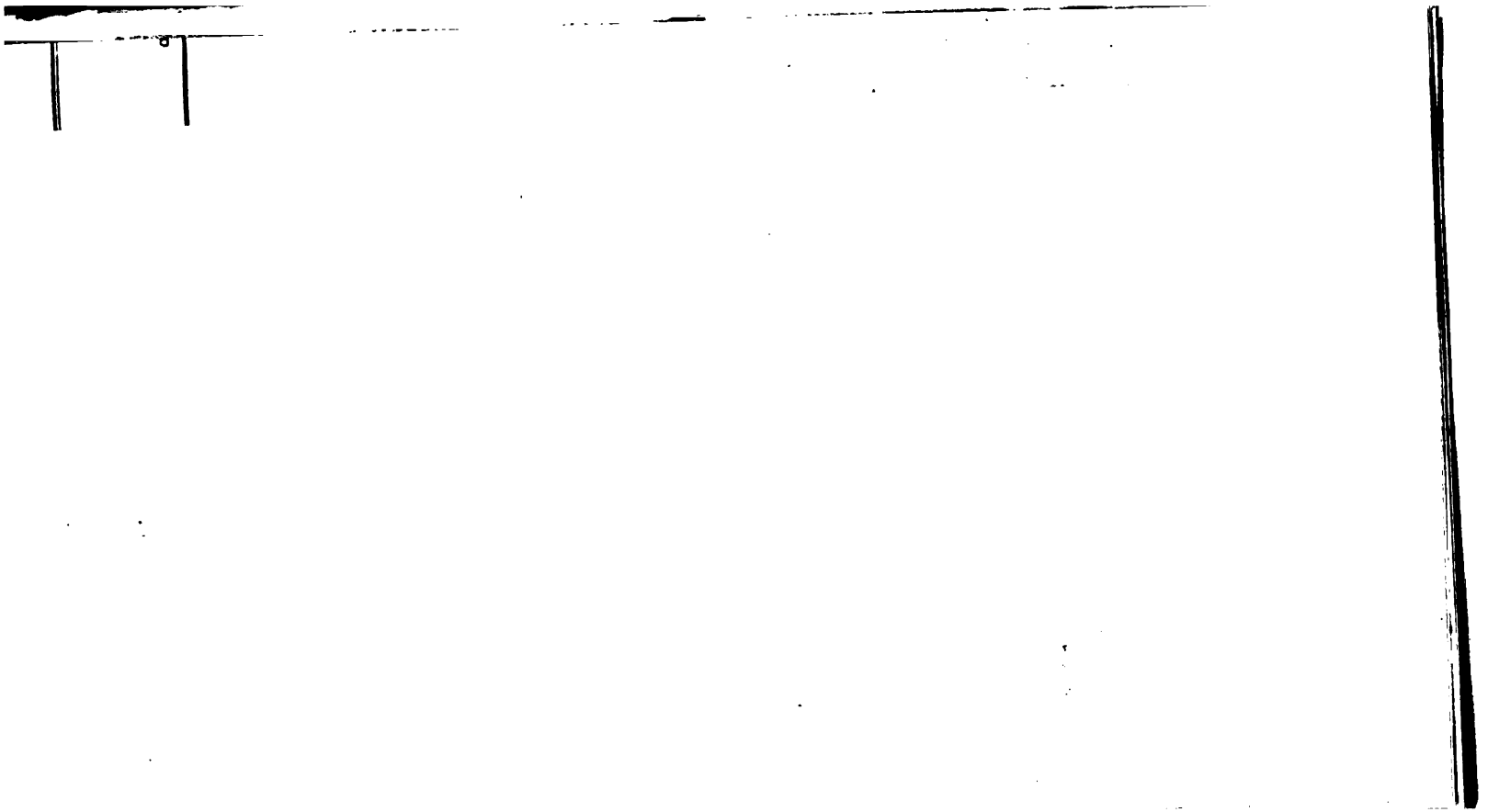
July 1, 1897, balance unexpended		$127,164.36
July 1, 1898, balance unexpended		127,164.36
Amount that can be profitably expended in fiscal year ending June 30, 1900		128,875.00
		†8,710.64

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

* This sum is derived by taking the amounts already appropriated for the work, i. e., $970,996, from the estimated cost of the work, i. e., $2,200,000. In explanation it may be said that the contract for the work has been let for $1,765,450.63, leaving $434,549.37 for engineering expenses, superintendence, office expenses, and all contingencies. It is quite probable that the work will be completed well within the estimate, but it is too early yet to say so positively or how much within the estimate, and it is deemed proper to leave the amount required for completion of existing project as above until the work is further advanced.

† Previous named amount less estimated balance on hand.





Statement of appropriations and allotments made for improving harbor at Buffalo, N. Y., from May 26, 1826, to the present time.

May 26, 1826	$15,000.00	March 3, 1873	$75,000.00
May 19, 1828	34,206.00	February 23, 1874	20,000.00
April 23, 1830	15,488.00	June 23, 1874	75,000.00
March 2, 1831	12,900.00	March 3, 1875	100,000.00
July 3, 1832	10,300.00	August 4, 1877	85,000.00
March 2, 1833	31,700.00	June 18, 1878	80,000.00
June 28, 1834	20,000.00	March 3, 1879	100,000.00
July 7, 1838	68,500.00	June 14, 1880	90,000.00
June 11, 1844	40,000.00	March 3, 1881	90,000.00
August 30, 1852	14,000.00	August 2, 1882	125,000.00
March 3, 1853	349.05	July 5, 1884	100,000.00
March 2, 1855	452.32	August 5, 1886	112,500.00
June 28, 1864	15,000.00	August 11, 1888	225,000.00
July 2, 1864	37,500.00	September 19, 1890	300,000.00
June 23, 1866	131,000.00	July 13, 1892	300,000.00
March 2, 1867	100,000.00	August 18, 1894	70,000.00
April 10, 1869	89,100.00	June 4, 1897	481,250.00
July 10, 1870	80,000.00	July 1, 1898	489,746.00
March 3, 1871	100,000.00		
June 10, 1872	75,000.00	Total	3,808,991.37

List of contracts in force at close of fiscal year.

Name of contractor.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.	Remarks.
Hughes Bros. & Banga, Syracuse, N. Y.	Jan. 27, 1897	Feb. 19, 1897	May 19, 1897	Jan. 1, 1901	For extension of breakwater and sand-catch pier.
Do	....do	....do	June 1, 1897	....do	For delivering stone in Canada for breakwater.
Do	Jan. 28, 1897	....do	....do	....do	For transporting stone from Canada to breakwater.
Do.a	Apr. 26, 1898	May 14, 1898	May 14, 1898	....do	

a Supplemental to contract of January 27, 1897.

COMMERCIAL STATISTICS OF BUFFALO HARBOR, NEW YORK.

[Compiled from records furnished by collector of customs, and from annual reports of the Merchants' Exchange of Buffalo, N. Y.]

Arrivals and departures of vessels for the year ending December 31, 1897.

Vessels from—	Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.
Domestic ports	4,208	5,279,205	4,340	5,482,805
Foreign ports	1,166	358,118	1,064	178,963
Total	5,374	5,637,323	5,404	5,661,768

Total arrivals and departures:	
Vessels	10,778
Tonnage	11,299,091
Increase of lake tonnage, 1897 over 1896, tons	215,885
Amount of revenue collected, year ending December 31, 1897	$222,881
Value of imports, year ending December 31, 1897	$4,453,477
Value of exports, year ending December 31, 1897	$6,116,957
Enrolled tonnage, port of Buffalo, 1897, gross tonnage	194,583

Includes for port of Tonawanda, embraced in Buffalo Creek district.

Receipts by lake.

Articles.	1893.	1894.	1895.	1896.	1897.
Barley	138,995	207,002	262,997	397,565	349,126
Corn	1,175,659	843,277	1,089,800	1,258,184	1,498,227
Corn meal	4,172	2,848	2,242	19,062	40,456
Flour	1,035,085	1,125,876	870,230	1,038,418	1,244,062
Oats	331,202	248,964	355,700	641,720	1,026,250
Rye	18,049	14,033	24,405	122,343	200,300
Wheat	2,047,313	1,505,824	1,417,680	1,648,824	1,714,709
Flaxseed	136,542	41,440	105,770	251,190	154,542
Feed	122,300	133,250	117,880	149,134	172,344
Malt	9,391	13,429	8,551	704	67,998
Oatmeal	.....	5,265	1,596	3,284	5,214
Pease	2,030	3,519	4,780	4,786	10,279
Oil cake	20,951	16,385	18,530	1,692	25,817
Seeds	6,397	2,384	946	7,518	7,788
Broom corn	.....	.....	30	1,180	1,090
Hops	.....	.....	28	50	55
Lumber	501,814	419,170	404,701	352,500	388,250
Timber	336,000	228,900	144,885	68,181	125,863
Laths	3,813	1,952	1,230	1,052	1,273
Shingles	6,097	12,613	11,110	12,479	13,348
Posts	168	553	2,701	730	.....
Ties	18,975	14,709	10,049	14,965	17,147
Staves	.....	340	480	778	847
Stave bolts	10,128	7,992	3,142	6,085	3,869
Copper	64,930	93,658	83,030	102,180	117,447
Copper matte	13,770	3,752	27,475	42,810	.....
Iron ore	243,442	306,670	500,994	443,073	609,628
Pig iron	33,950	26,324	33,122	18,935	38,101
Lead, pig	34,488	21,855	16,877	31,328	15,864
Spelter plates	9,902	12,400	6,855	10,860	6,097
Cheese	66	75	238	200	359
Fish	.....	.....	4,742	3,935	4,153
Glucose	43,262	73,012	22,982	109,636	115,868
Hay	58,171	44,324	1,300	18,896	10,772
Lard	15,559	61,501	16,895	45,397	42,000
Pork	1,354	3,666	262	3,412	3,895
Soap	525	474	273	1,035	1,422
Starch	840	1,651	800	2,410	2,615
Wool	2,390	7,315	3,167	5,772	8,000
Cement	.....	.....	.....	.....	868
Oil	.....	.....	580	11,955	2,136
Paper	.....	.....	.....	1,470	573
Pelts	.....	.....	.....	.....	1,446
Potatoes	.....	.....	.....	.....	3,666
Rags	.....	.....	1,135	976	1,522
Raisins	.....	.....	.....	14	366
Tallow	.....	.....	1,222	6,523	5,441
Whisky	.....	.....	10	146	431
Headings	.....	.....	.....	716	1,745
Total	6,447,730	5,506,402	5,581,428	6,864,097	8,062,151

Receipts by lake, in tons and percentages, during the calendar years 1896 and 1897.

Articles.	1896.		1897.	
	Tons.	Per cent.	Tons.	Per cent.
Grain, flour, malt, and seed products	5,545,648	80.79	6,517,347	80.84
Lumber and timber products	456,770	6.66	550,496	6.83
Ores and metals	649,186	9.45	787,157	9.76
Miscellaneous	212,493	3.10	207,151	2.57
Total	6,864,097	100	8,062,151	100

Shipments by lake.

Articles.	1893.	1894.	1895.	1896.	1897.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Coal	2,703,673	2,485,255	2,620,768	2,400,068	2,234,339
Cement and plaster	65,156	71,413	78,766	94,466	115,467
Salt	37,361	104,845	100,362	94,134	112,110
Railroad iron	7,317	980	.....	.....	.....
Sugar	119,426	196,977	192,004	211,384	224,207
Total	2,932,933	2,859,470	2,991,900	2,800,052	2,686,053

Shipments by lake during the calendar years 1896 and 1897.

Articles.	1896.		1897.	
	Tons.	Per cent.	Tons.	Per cent.
Coal	2,400,068	85.73	2,234,329	83.19
Cement and plaster	94,466	3.36	115,407	4.29
Salt	94,134	3.36	112,110	4.17
Sugar	211,384	7.55	224,207	8.35
Total	2,800,052	100	2,686,053	100

The following statistics of the canal commerce of Buffalo are also compiled from the report of the Buffalo Merchants' Exchange:

	1896.	1897.
Canal clearances	5,788	4,609
Tonnage of freight coming to Buffalo	398,191	377,679
Tonnage of freight leaving Buffalo	1,172,552	830,285
Number of steamers and canal boats navigating from Buffalo on the canal, about	1,250	1,250
Average freight rate, Buffalo to New York, for wheat and corn, per bushel	$0.037	$0.028

The following gives the canal clearances for the last twelve years:

1886	7,414	1892	5,460
1887	7,925	1893	7,725
1888	5,958	1894	6,621
1889	6,855	1895	4,546
1890	6,429	1896	5,788
1891	6,312	1897	4,609

For comparison, the following statement of the last four years is given:

	1894.	1895.	1896.	1897.
Tons of articles received by canal	413,631	355,134	398,191	377,679
Tons of articles sent by canal	1,437,293	709,346	1,172,552	830,285
Value of articles received	$24,760,803	$30,299,568	$35,636,664	$37,166,685
Value of articles sent	$37,865,302	$20,279,881	$31,608,123	$18,402,447
Barrels of flour sent	3,028	900	64,550	15,414
Bushels of grain sent	48,428,521	20,236,114	35,709,258	25,430,601

Assuming that the number of arrivals of canal boats equaled the number of clearances, the grand total of the commerce of Buffalo carried on by lake, river, and canal for the seasons of 1896 and 1897 is as follows:

By—	Arrivals and departures.		Receipts of freight.		Shipments of freight.	
	1896.	1897.	1896.	1897.	1896.	1897.
			Tons.	*Tons.*	*Tons.*	*Tons.*
Lake and river	10,446	10,778	6,864,097	8,062,151	2,800,052	2,686,053
Canal	11,576	9,218	398,191	377,679	1,172,552	830,285
Total	22,022	19,996	7,262,288	8,439,830	3,972,604	3,516,338

Total receipts and shipments, 1896, 11,234,892; 1897, 11,956,168.

The amount of wheat and breadstuffs going east by canal in 1895 was the lowest for many years, and the canal freights were the lowest ever known, the average rate, Buffalo to New York, for wheat and corn having been only 2.2 cents.

The business on the canal picked up during 1896, but it fell off during 1897 to nearly the amounts of freight and rates of carriage reached in 1895.

N N 4.

IMPROVEMENT OF TONAWANDA HARBOR AND NIAGARA RIVER, NEW YORK.

Original condition.—In its original condition the navigation of the Niagara River from Lake Erie to Tonawanda was obstructed by several reefs and hummocks, which materially limited the draft of the vessels traversing it. The water in the harbor between Tonawanda Island and the main shore was shoal, and in the river in some places had a very swift current. The object of the improvement is to provide a navigable channel from the head of the Niagara River at Lake Erie to the north end of Tonawanda Harbor, and to dredge that harbor all to a depth permitting use by vessels drawing 16 feet.

Project for improvement.—To remove obstructions so as to make a channel 400 feet wide and 18 feet deep, which includes work at the following places:

1. On the "Horseshoe Reef" at the entrance to Niagara River.
2. On the shoal at the head of Strawberry Island.
3. A few shoal places abreast of the lower end of Rattlesnake Island.
4. The full width of the river between Tonawanda Island and the mainland along the entire front of Tonawanda.

This project was approved in 1888.

By the terms of the river and harbor act of June 3, 1896, the project was extended to include the river to the north line of the village of North Tonawanda.

The cost of the work, as estimated in 1891, was $1,152,987.93. This does not include the work necessary between Tonawanda Island and the north line of the village of North Tonawanda, nor that required in the main river abreast of Tonawanda Island, to which the project was extended by the terms of the river and harbor act of June 3, 1896. The amount expended on the general project up to June 30, 1897, was $338,457.16.

At that time the channel through the Horseshoe Reef had been completed. This channel, as completed, is 400 feet wide and 18 feet deep at mean lake level, excepting a few small patches of rock, over which there is a least depth of 17½ feet. The length of the channel is 1,500 feet.

The amount expended during the fiscal year ending June 30, 1898, was $11,336.21.

At the close of operations in January, 1897, the channel across the reef at Strawberry Island had been excavated to the depth of 18 feet for a width of 180 feet. No work has been done on this reef since. The remainder of this channel, which is to be 400 feet wide, is 15 to 16 feet deep.

During the season of 1896 a channel 200 feet wide and 1,050 feet long was excavated full 18 feet deep across the shoal in the main river channel at the foot of Tonawanda Island. Tonawanda Harbor had been dredged 16 feet deep in the center during previous years. The work of increasing the depth in the harbor to 18 feet was begun in 1895, when a dredge cut 20 feet wide was made to the depth of 18 feet along nearly all of the length of the harbor front of Tonawanda Island. During 1897 the money available was expended in securing a similar depth along 1,600 feet of the docks on the mainland side below the bridge for a width of 75 feet. This work was stopped on account of exhaustion of funds on July 6, 1897, and no work has been done since.

The object of the extension of the project to the north line of North Tonawanda was to enable needed work to be done on a shoal off the foot of Tonawanda Island, which work was not included in the original project and estimates. At some distance below the island there is a deep pool, and by excavating across the shoal this could be reached. Beyond the pool no work is demanded by any present interests of commerce.

REPORT OF OPERATIONS.

There were practically no operations carried on during the fiscal year. At its beginning dredging along the docks on the mainland side of Tonawanda Harbor below the bridge was still in progress, but was stopped on July 6, 1897, because of the exhaustion of funds. As vessels were reported to be striking bottom on shoal spots in the main river channel outside of Tonawanda Island, a test of this channel was made on July 6, 1897, and the shoals located. Two dredges were operated on these shoals July 7 and 8, 1897, when all operations were stopped on account of exhaustion of funds.

The cost of dredging at Tonawanda Harbor was 27½ cents per cubic yard, scow measure, of clay, gravel, and hardpan. The work was all done under contract of September 14, 1896.

The laying of a waterworks force main across Tonawanda Harbor and an intake pipe from the west side of Tonawanda Island out in Niagara River to a new waterworks intake crib was completed in September, 1897. This work was done by the board of water commissioners of the village of North Tonawanda under authority of the Secretary of War, dated September 22, 1896. A force main was laid across Tonawanda Harbor from the mouth of the State ditch, just above the Tonawanda Iron and Steel Company's furnaces, to the island. This force main was a 24-inch cast-iron pipe, and was laid at a depth of not less than 22 feet over top of pipe at mean river level.

The intake pipe was a 48-inch steel pipe, extending from the North Tonawanda pump house on the outer shore of Tonawanda Island to a new intake crib 1,200 feet out in the river. The intake was laid at a depth of 22 feet over top of pipe at mean river level.

REMARKS.

The originally estimated cost of the project in 1891 was $1,152,987.93. A very large part of the work embraced by the project and its extension has been done at a cost much below the original estimate.

Taking the sum of the appropriations, $350,000, from the original estimates leaves $802,987.93. The knowledge gained in the conduct of the work indicates that but a portion of this sum will be required to do all the necessary work embraced in the original project, and all work that is at all required in the extension of the project.

It may be explained that the project was extended to the north line of the village of North Tonawanda in order to enable work to be done on the shoal just north of Tonawanda Island and abreast of this island. No good purpose would be subserved by extending the channel 400 feet wide and 18 feet deep through the shoal river along the north front of North Tonawanda.

Recent experiences of vessels and an examination made by this office indicate a lumpy condition and some shoal ridges in the main channel abreast of Tonawanda Island, which will require much work to give the projected channel 18 feet depth and 400 feet width. This work is

not specified or estimated for in the original project and estimate, but properly comes within the extended project.

The commerce of Tonawanda is large and increasing, and it is in a high degree desirable that all impediments be removed which interfere with vessels drawing 16 feet of water reaching the docks. An appropriation of $250,000 is estimated for as the amount which can profitably be expended during the next fiscal year under the project.

Money statement.

July 1, 1897, balance unexpended	$11,543.84
June 30, 1898, amount expended during fiscal year	11,336.21
July 1, 1898, balance unexpended	207.63
Amount (estimated) required for completion of existing project	802,987.93
Amount that can be profitably expended in fiscal year ending June 30, 1900	250,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
August 11, 1888	$100,000
September 19, 1890	75,000
July 13, 1892	75,000
August 18, 1894	50,000
June 3, 1896	50,000
Total	350,000
May, 1897, repayment	1
Total	350,001

COMMERCIAL STATISTICS OF TONAWANDA HARBOR AND NIAGARA RIVER, NEW YORK, BY LAKE AND RIVER.

[Furnished by collectors of customs, Buffalo Creek and Niagara districts.]

Arrivals and departures of vessels for the year ending December 31, 1897.

District.	Vessels.	Arrivals from—				Departures to—			
		Home ports.		Foreign ports.		Home ports.		Foreign ports.	
		Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
Buffalo Creek..	Steam	175	85,622	96	773	183	54,815	79	1,334
	Sail and barges	165	49,227	9	1,131	181	88,211	11	2,047
Niagara	Steam	405	156,451	20	6,714	415	155,179	15	6,540
	Sail and barges	514	244,884	36	13,018	515	243,681	20	6,932
Total		1,259	536,184	161	21,636	1,294	541,886	125	16,853

Total arrivals and departures (registered tonnage).

District.	1896.				1897.			
	Arrivals.		Departures.		Arrivals.		Departures.	
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
uffalo Creek	437	126,015	439	124,521	380	136,753	408	146,407
iagara	874	339,249	842	327,659	975	421,067	965	412,332
Total	1,311	465,264	1,281	452,180	1,355	557,820	1,373	558,739

ncrease of tonnage, 1897 over 1896	registered tons..	199,115
reatest draft of vessels	feet..	14
mount of revenue collected, year ending December 31, 1897		$1,848.45
alue of foreign imports, year ending December 31, 1897		$292,597.94
alue of foreign exports, year ending December 31, 1897		$3,842.00
nrolled tonnage, port of Tonawanda		No record.
ew lines of transportation established		None.
umber of rafts of timber received		15

Receipts by lake and river.

Articles.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Lumber	884,646	871,508	752,936	712,087	737,202	821,797	1,024,232
Shingles	6,307	5,137	3,031	3,776	4,957	4,298	5,948
Laths	2,052	1,561	3,308	2,124	2,137	1,798	1,882
Pickets		991				135	
Posts				1,200	1,167	4,059	2,889
Railroad ties, telegraph poles, etc	8,092	21,333	5,152	2,514	7,350	5,972	2,196
Iron ore		85,772	66,617	93,684	110,454	134,428	172,187
Limestone		7,728	11,868		21,720	4,770	4,353
Pig iron		1,440	1,460	4,370	8,371	9,097	2,403
Copper				700			
Pulpwood		900	15,770	17,812		25,270	19,720
Timber					1,050	3,772	5,057
Total	901,097	996,370	860,142	838,267	894,408	1,015,396	1,240,867

Shipments by lake and river.

Articles.	1897.
	Tons.
Lumber	928
Pig iron	500
Manufactured iron	200
Total	1,628

Receipts in tons and percentages for the years ending December 31, 1895, 1896, and 1897.

Articles.	1895.		1896.		1897.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Timber and timber products	753,863	84.28	867,101	85.4	1,061,924	85.58
Iron, copper, etc	140,545	15.72	148,295	14.6	178,943	14.42
Total	894,408	100	1,015,396	100	1,240,867	100

The following table, giving the entrances and clearances at Tonawanda since 1890, is compiled from the annual report of the Buffalo Merchants' Exchange:

	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Vessels entered ..No..	1,331	1,151	909	849	949	1,311	1,355
Vessels cleared ..do...	1,119	1,175	894	830	951	1,291	1,369
Entering vessels..tons.	469,627	484,038	400,479	418,438	425,105	466,297	557,748
Clearing vessels..tons.	455,115	473,997	391,175	403,350	441,602	455,000	553,786
Articles received by lake in vessels, rafts, etc.....tons..	901,997	996,376	860,142	838,267	894,408	1,015,396	1,240,867
Canal clearances..No..	.....	3,111	2,502	2,258	2,120	2,062	2,735
Shipments by Erie Canal.....tons..	649,684	584,212	550,864	436,260	403,358	384,889	502,527
Lumber shipments by Erie Canal..feet B. M.	293,211,900	286,329,307	216,116,582	202,110,960	195,886,000	185,580,352	218,576,701

Number of vessels and rafts passing the International Bridge, Niagara River, during the years 1891 to 1897.

[Furnished by R. J. McMurray, captain of the bridge tug *International*.]

Vessels.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Steamers	9,597	10,132	8,796	10,408	10,012	9,469	8,100
Other vessels	3,544	3,872	2,820	3,075	2,891	1,833	2,321
Rafts	61	40	25	13	5	13	10
Total	13,202	14,044	11,641	13,478	12,908	11,315	10,431

Number of vessels passing through the draw of the International Bridge.

Vessels.	1896.	1897.
Tugs	3,213	4,250
Steamers	2,856	
Barges	1,608	2,321
Total	7,677	6,571

Season of navigation, April to December, 1897.....days.. 270
Number of times the bridge draw was opened during the season 4,741
Average number of times bridge draw was opened per day 17.55

N N 5.

IMPROVEMENT OF NIAGARA RIVER FROM TONAWANDA TO PORT DAY, NEW YORK.

Original condition.—Port Day is the inlet to the old hydraulic-power canal at Niagara Falls. It is not and never has been a practicable port of commerce, owing to shallow water and its proximity to the rapids at the head of Niagara Falls.

From Port Day up, the river in front of the city of Niagara Falls is very shallow and with rock bed until Conners Island is reached. Between Conners Island and the main shore is a snug little harbor, with about 5 acres, of an average depth of 12 feet at mean river stage and with a maximum depth of about 18 feet.

Above the head of the island there was a shoal with a least depth on it of 7½ feet at mean stage. Above this shoal very good water existed until Cayuga Island was reached. Between this island and Tonawanda a shoal exists which requires dredging to give a channel of 12 feet depth at mean river stage.

Project for improvement.—The project for the improvement of the Niagara River from Tonawanda to Port Day as it now stands is to make a channel 200 feet wide and not less than 12 feet depth at mean water level, by excavating through the shoal at the head of Conners Island and through the shoal above Cayuga Island.

The project also states that "any widening or deepening required should be estimated and provided for after the work outlined above is done."

This is a modification of the original project which, with a history of the modification, is given in the annual report on this harbor for 1896. (Chief of Engineers' Report, 1896, p. 3122.)

The cost of the present project was originally estimated in 1892 at $230,000.

This estimate was reduced to $180,000, and it is now determined that the work can be completed for much less than this amount, viz, $50,000, making the total cost of the work contemplated by the project $95,000.

Up to June 30, 1897, there had been expended on the project $28,936.55. At this time the channel through the shoal at the head of Conners Island had been completed to its full width of 200 feet and a depth of 12 feet or more at mean river level. A survey was made September–November, 1896, of the river from Tonawanda to Schlossers Dock. The map of this survey gave data for a careful study of the river and for plans of improvement, which consisted in laying out approximate pierhead lines 2,000 feet apart along the river banks to define the free river waterway. Within these limits a channel 200 feet wide was located from Tonawanda to Conners Island, which channel was found to have 12 feet or more depth of water, except across a rock ledge above Cayuga Island, about 1,000 feet long, and over scattered bowlders above it. Drilling and blasting rock in the proposed channel across this shoal had been fairly begun at the beginning of the fiscal year.

The amount expended during the fiscal year ending June 30, 1898, was $15,452.92.

REPORT OF OPERATIONS.

Drilling and blasting rock in the channel across the shoal above Cayuga Island was begun on June 21, 1897, and the work was carried on continuously day and night until July 28, 1897, when the drill boat was discharged. An area 81 feet wide and extending entirely across the shoal, 936 feet, was drilled and blasted.

The following is a summary of this work:

Area drilled and blasted	square yards..	8,424
Number of days' work of drill boat		74.875
Amount earned by drill boat		$5,690.50
Cost per square yard drilled and blasted		$0.675+
Number of holes drilled		810
Area per hole drilled	square yards..	10.4
Average depth of holes	feet..	3.94+

Dredging of the blasted area was begun with one dredge on July 9, 1897, and continued until October 29, 1897, when the dredging of this

area was completed, and operations were stopped owing to the exhaustion of funds.

The season's operations resulted in securing a channel across the shoal above Cayuga Island 81 feet wide at its upper end and 100 feet wide at its lower end, and not less than 12 feet deep at mean river level. The total length of the dredged channel was 1,040 feet.

The following is a summary of the dredging operations:

Number of days' work of dredge and tug	124.07
Number of cubic yards blasted rock dredged	24,185
Amount earned by dredge and tug	$9,135.90
Cost per cubic yard dredged, scow measure	$0.377

The following is a summary of the cost of channel excavation, including drilling, blasting, and dredging rock:

Number of cubic yards rock drilled, blasted, and dredged	24,185
Amount earned by dredge and drill boat	$14,826.40
Cost per cubic yard excavated, scow measure	$0.613+
Cost per cubic yard, estimated place measure	$1.65

The work was done with hired plant. No other operations were carried on during the fiscal year 1898.

REMARKS.

With the completion of the channel 200 feet wide and 12 feet deep through the Cayuga Island reef, and the removal of any bowlders that may be elsewhere discovered, the project may be considered as completed.

It is estimated that it will cost $50,000 to complete the work on this shoal and elsewhere under the project, and it is therefore recommended that this sum be appropriated to complete the project.

It is to be noted that there is practically no use made of this channel of the Niagara River below Tonawanda, except by excursion boats running to resorts along the shore of Grand Island.

Money statement.

July 1, 1897, balance unexpended	$16,063.45
June 30, 1898, amount expended during fiscal year	15,452.92
July 1, 1898, balance unexpended	610.53
Amount (estimated) required for completion of existing project	50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
July 13, 1892	$20,000
August 18, 1894	10,000
June 3, 1896	15,000
Total	45,000

COMMERCIAL STATISTICS, NIAGARA FALLS, NEW YORK.

Arrivals and departures for the year ending December 31, 1897.

	Excursion steamers and tugs.	
	Number.	Tonnage.
from home ports	19	964
res to home ports	19	964

ivals and departures of vessels (tonnage 1,928)	38
of tonnage from 1896	53,700
draft of vessels ..... feet..	10
of revenue collected, year ending December 31, 1897	None.
foreign imports, year ending December 31, 1897	None.
foreign exports, year ending December 31, 1897	None.
tonnage, port of Niagara Falls	No record.
s of transportation established	None.

Receipts by river at Schlossers Dock.

	1895.	1896.	1897.
d.....tons..	300	None.	None.
.....do...	100	None.	None.
tal	400		

cord of passengers.

e was unloaded from vessels at foot of Grand Island and rafted to Port Day paper mills the following:

	Pulpwood.		Pulpwood.
	Tons.		*Tons.*
	28,000	1896	36,000
	28,284	1897	70,764

nents by river, none, except passengers, which are not reported.

N N 6.

IMPROVEMENT OF WILSON HARBOR, NEW YORK.

ginal condition.—Wilson Harbor is at the mouth of Twelve Mile , a small stream flowing into Lake Ontario. In its original con- there was a depth of water inside the mouth sufficient for ordi- ized lake craft, but it was closed by a bar upon which there was arily but about 1 foot of water. The object of the improvement taken was to obtain a channel of 12 feet depth from deep water in eek to deep water in Lake Ontario.

ject.—The present project was submitted in 1873 and proposed to d piers to the 12-foot curve in Lake Ontario and to dredge a chan- feet deep between the piers and from the shore end of the piers to ep water in the creek.

original estimated cost of the work, as made in 1873, was $90,000. was increased in 1877 to $100,000.

The amount expended upon the project to June 30, 1897, was $69,962.92. With this money there had been built two piers at the harbor entrance and a shore protection; the piers were repaired in 1896 and the channel dredged as far as the funds would allow. The piers are prolongations of piers built by private parties in 1846. At present the west pier is 832 feet long and the east pier 850 feet long. There is also a shore protection for the east pier. This is 360 feet long.

The channel was dredged in 1889 to a minimum depth of about 9 feet, but had shoaled since that time. During the fiscal year ending June 30, 1897, the channel was again dredged out.

At the close of the work the channel had been dredged to its full depth of 12 feet and 80 feet wide from the lake to the docks in the harbor. The material was found to be sand and gravel, with a ledge of red shale underlying the outer 400 feet of the channel. This shale was removed by the dredge without material difficulty and required no blasting.

In connection with the dredging the piers were repaired to the extent permissible with the available funds. The superstructures of both piers were filled with stone where needed, which was at their outer ends, and the decks repaired to protect the new filling.

No money was expended during the fiscal year ending June 30, 1898.

REPORT OF OPERATIONS.

Nothing was done toward the improvement of this harbor during the fiscal year ending June 30, 1898.

REMARKS.

The work at Wilson Harbor was never completed, but has been in hand since 1873. The existing piers are badly in need of repairs, and the channel between the piers becomes choked with sand and gravel.

The money appropriated by the act of June 3, 1896, was expended in making absolutely necessary minor repairs and in dredging as good a channel as possible.

To put this harbor in the condition which is called for by the project will cost about the difference between the estimated cost of $100,000 and the amount already appropriated, $70,000—that is, $30,000. Of this, $15,000 will be required for renovation of the piers and $15,000 for dredging.

About the only business of Wilson by water is the excursion business. Upon Twelve Mile Creek there are some beautiful picnic grounds with suitable buildings, and several times during the summer boats bring parties of excursionists, chiefly from Canada.

Money statement.

July 1, 1897, balance unexpended	$16.09
July 1, 1898, balance unexpended	16.09
Amount (estimated) required for completion of existing project	30,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	30,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Statement of appropriations.

March 3, 1875	$10,000.00	June 3, 1896	$5,000.00
August 14, 1876	10,000.00		
June 14, 1880	10,000.00	Total	70,000.00
March 3, 1881	10,000.00	May 12, 1897, repayment to appropriation	.50
August 2, 1882	10,000.00		
August 5, 1886	10,000.00		70,000.50
August 11, 1888	5,000.00		

Twenty-one dollars and forty-nine cents from the appropriation of August 11, 1888, remained unexpended and was turned into the Treasury January 22, 1896.

COMMERCIAL STATISTICS, WILSON HARBOR, NEW YORK.

[Furnished by the deputy collector of customs at Wilson, N. Y.]

Arrivals and departures for the year ending December 31, 1897.

	Steam vessels.	
	Number.	Tonnage.
Arrivals from foreign ports	7	1,920
Departures to foreign ports	7	1,920

Total arrivals and departures of vessels (tonnage, 3,840)		14
Decrease of tonnage from 1896		6,010
Greatest draft of vessels	feet..	10
Amount of revenue collected, year ending December 31, 1897		$5.40
Value of foreign imports, year ending December 31, 1897		$32.00
Value of foreign exports		None.
Enrolled tonnage, port of Wilson, N. Y.		None.
New lines of transportation established		None.

Receipts and shipments by lake for the years 1896 and 1897.

Articles.	Receipts.		Shipments.	
	1896.	1897.	1896.	1897.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Lumber	893	.....	.....	.....
Fruit	0.25	.....	0.25	.....
Lath	25	.....	.....	.....
Cedar posts	360	.....	.....	.....
Shingles	18	.....	.....	.....
Beer, 12 dozen bottles	.....	0.20	.....	.....
Total	1,296.25	.20	.25	

The following table gives the total arrivals at and departures from Wilson Harbor, New York, for the last ten years.

Year.	Vessels arriving and departing.		Year.	Vessels arriving and departing.	
	Number.	Tonnage.		Number.	Tonnage.
1888	43	5,963	1893	99	35,860
1889	126	27,996	1894	78	27,188
1890	102	25,258	1895	106	41,820
1891	89	19,731	1896	42	9,850
1892	54	19,992	1897	14	3,840

APPENDIX O O.

IMPROVEMENT OF HARBORS ON LAKE ONTARIO EAST OF OAK ORCHARD, NEW YORK, AND OF RIVERS AND HARBORS IN NORTHERN NEW YORK.

REPORT OF MAJ. W. S. STANTON, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Charlotte Harbor, New York.
2. Harbor at Great Sodus Bay, New York.
3. Harbor at Little Sodus Bay, New York.
4. Oswego Harbor, New York.
5. Harbor at Sackett's Harbor, New York.
6. Harbor at Cape Vincent, New York.
7. Shoals between Sister Islands and Cross-over Light, St. Lawrence River, New York.
8. Ogdensburg Harbor, New York.

UNITED STATES ENGINEER OFFICE,
Oswego, N. Y., June 30, 1898.

GENERAL: I have the honor to transmit herewith annual reports for the fiscal year ending June 30, 1898, upon the works of river and harbor improvement under my charge.

Very respectfully, your obedient servant,

W. S. STANTON,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

O O 1.

IMPROVEMENT OF HARBOR AT CHARLOTTE, NEW YORK.

This harbor is in the Genesee River. Its improvement has consisted in deepening the channel on the bar at the mouth of the river from 8 feet in 1829 to 16 feet in 1898, by building two jetties of cribs of timber ballasted with stone, and by dredging. A plan of the improvement faces page 2458 in the Report for 1894 and its history is given on pages 3131–3137 of the Report for 1896.

In 1882 the project was adopted to obtain the depth of 15 feet in the channel at low water (zero of the Oswego gauge) by extending the two piers an aggregate length of 3,250 feet to the 15-foot curve in the lake, and by dredging.

July, 1896, when 1,444 feet of this pier extension had been constructed, the project was modified by the Chief of Engineers to obtain and preserve the depth of 16 feet at low water by dredging without further extension of the piers, at least for the present, which is the project in pursuance of which funds are now applied.

During the fiscal year ending June 30, 1898, 49,973.4 cubic yards of mud, silt, and sand were dredged from the channel by W. J. Daly, of

Ogdensburg, N. Y., under written proposal and written acceptance, at 15 cents per cubic yard, measured in scows, Mr. Daly's proposal, in response to advertisement, to do the dredging by formal contract for 18 cents per cubic yard having been rejected.

Minor repairs were made to the decks of the jetties.

A survey made by Asst. Engineer John C. Churchill, jr., in January, 1898, showed that there was a channel 16 feet deep, at zero of the Oswego gauge, 125 feet wide. Another survey made June 28, 1898, shows that there is now a channel 150 feet wide and 15½ feet deep at same stage. To restore the channel to a depth of 16 feet and width of 150 feet will require the removal of 10,000 cubic yards of material.

The sediment deposited by the Genesee River in freshets necessitates more or less dredging annually to maintain the depth of 16 feet in this channel.

Commencing about 120 feet from its outer end, 453 linear feet of the east pier is somewhat dilapidated, but will need only minor repairs for the next few years.

It is estimated that there may be required to June 30, 1900:

For dredging, office expenses, surveys, and superintendence	$5,500
For repairs to piers	1,500
Total	7,000

The total commerce at this port during the calendar year ending December 31, 1897, was 385,981 tons, of which 372,713 tons were coal brought by rail from the mines in Pennsylvania to Charlotte; 81.1 per cent of it was shipped down the St. Lawrence, 17.3 per cent to Canadian ports on Lake Ontario, and 1.6 per cent through the Welland Canal.

Charlotte is in the collection district of Genesee, N. Y.

Money statement.

July 1, 1897, balance unexpended	$9,406.19
June 30, 1898, amount expended during fiscal year	8,931.64
July 1, 1898, balance unexpended	474.55
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	7,000.00

Appropriations.

Date.	Amount.	Aggregate.	Date.	Amount.	Aggregate.
May 23, 1828	$300.00	$300.00	April 10, 1869 a	$1,000.00	$281,578.45
March 2, 1829	10,000.00	10,300.00	July 11, 1870	12,000.00	293,578.45
March 3, 1829	13,335.00	23,635.00	March 3, 1871	10,000.00	303,578.45
March 2, 1831	16,670.00	40,305.00	March 3, 1875	5,000.00	308,578.45
February 24, 1832	16,000.00	56,305.00	June 18, 1878	1,000.00	309,578.45
March 2, 1833	15,000.00	71,305.00	March 3, 1879	1,000.00	310,578.45
June 28, 1834	20,000.00	91,305.00	June 14, 1880	5,000.00	315,578.45
March 3, 1835	2,390.00	93,695.00	March 3, 1881	2,500.00	318,078.45
July 2, 1836	20,000.00	113,695.00	August 2, 1882	35,000.00	353,078.45
March 3, 1837	10,000.00	123,695.00	July 5, 1884	20,000.00	373,078.45
July 7, 1838	25,000.00	148,695.00	August 5, 1886	26,250.00	399,328.45
June 11, 1844	10,000.00	158,695.00	August 10, 1888	45,000.00	444,328.45
August 20, 1852	20,000.00	178,695.00	September 19, 1890	25,000.00	469,328.45
March 3, 1853	176.10	178,871.10	July 13, 1892	25,000.00	494,328.45
June 28, 1864	25,000.00	203,871.10	August 18, 1894	15,000.00	509,328.45
June 23, 1866	75,607.30	279,478.40	June 3, 1896	12,000.00	521,328.45
July 25, 1868	1,100.00	280,578.40			

a Allotment.

COMMERCIAL STATISTICS.

Class of goods.	Net tons.	Class of goods.	Net tons.
Coal	872,713	Lumber	544
Grain	925	Pulp wood	288
Poles and railroad ties	5,528	Oil	149
Posts and wood	3,871	General merchandise	673
Shingles	689		
Iron	661	Total	885,981

Decrease since last year, 12,259 tons; passengers carried, 48,402.
Navigation opened April 30 and closed December 13, 1897.

Statement of vessels at Charlotte Harbor, New York, for calendar year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home	699	132,162	26	4,926	31	9,663
Foreign	292	147,276	162	28,465	209	83,308
Total	991	279,438	188	33,391	240	92,971
American owned	704	128,075	10	1,370	172	60,160
Canadian owned	287	151,363	178	32,021	68	32,811

Total arrivals, 1,419; registered tonnage, 405,800.

DEPARTURES.

Home	719	154,776	22	3,430	19	5,883
Foreign	273	124,688	165	29,917	221	87,088
Total	992	279,464	187	33,347	240	92,971

Total departures, 1,419; registered tonnage, 405,782.

Greatest draft of vessel.....feet.. 15½
Greatest tonnage of vessel.....registered tonnage.. 1,123
Greatest load of vessel.....net tons.. 1,670

O O 2.

IMPROVEMENT OF HARBOR AT GREAT SODUS BAY, NEW YORK.

The improvement has consisted in protecting the harbor by building a breakwater between the bay and Lake Ontario, and in deepening the entrance channel by building two jetties and by dredging. The breakwater and jetties consist of cribs of timber ballasted with stone.

A plan of the improvement faces page 2468 of the report for 1894, and there is a history of the improvement and a description of the bay in the report for 1896, pages 3139–3144.

In 1882 the project was adopted to obtain the depth of 15 feet at low water (zero of the Oswego gauge) by extending the piers to the 15-foot curve in the lake and by dredging. (See p. 2442, Report for 1881.) The total extension of both piers then required to reach that curve was 1,100 feet. July 18, 1896, when the two piers had been extended a total length of 539 feet, the Chief of Engineers authorized the depth of 15 feet to be obtained and maintained by dredging without further extension of piers into the lake, at least for the present, the funds then available to be applied to dredging a channel 15 feet deep and 150 feet

wide between the piers, flaring to 250 feet in width at the 15-foot curve, and to maintenance of the piers and of the United States dredging plant, which is the project in pursuance of which funds are now applied.

During the fiscal year 1,000 cubic yards of hardpan were dredged from the east side of the entrance by Mr. W. J. Daly, of Ogdensburg, N. Y., under written proposal and written acceptance, at 50 cents per cubic yard; and the following alterations and repairs have been made to the United States dredging plant: The spud casings of the dredge *Frontenac* have been removed from the hold and placed outboard. The machinery for hoisting the spuds and for throwing a part of the weight of the dredge upon the spuds has been provided and installed. The engines and machinery have been thoroughly overhauled and repaired and minor repairs made to the hull, which, with its superstructure, has been painted. Two trusses have been built in each of the two scows and the scows further strengthened by building two cross bulkheads, shortening the pockets, and the scows entirely recalked. The total cost of these alterations and repairs, including outstanding liabilities, has been $4,250, divided among the appropriations for improving harbors at Charlotte, Great Sodus, Little Sodus, Oswego, and Sacketts Harbor, of which $1,700 has been defrayed from the appropriation for this improvement.

A survey of the channel made by Assistant Engineer John C. Churchill, jr., May 31, 1898, shows that the channel 15 feet deep and 150 feet wide throughout from the bay to the lake, which was completed in August, 1897, had shoaled so that there was a channel 14½ feet deep, with a minimum width of 100 feet, and that the minimum width of the channel 15 feet deep was only 25 feet. To restore this channel to the depth of 15 feet and width of 150 feet and to increase it to the width of 250 feet at its mouth will require the dredging of about 40,000 cubic yards, at an estimated cost of $6,000.

The sand driven into the channel by the sea and from the west pier by the wind necessitates annual dredging to maintain the depth of 15 feet.

Seven hundred and eighty-one linear feet of the west pier and 350 feet of the east pier require a new deck, plank, stringers, and cap timbers. The timbers next below the cap timbers also require renewal on the east side of the east pier.

It is estimated that there will be required to June 30, 1900, for dredging, office expenses, surveys, and superintendence, $9,000, and for repairs to piers $5,000; total, $14,000.

The total commerce at this port during the calendar year ending December 31, 1897, was 53,548 tons, of which 53,129 tons were coal, which is transported from various mines in Pennsylvania by rail to Great Sodus, and of which 83.7 per cent was shipped down the St. Lawrence River and 16.3 per cent to Canadian ports on Lake Ontario. Great Sodus is in the collection district of Oswego, N. Y.

Money statement.

July 1, 1897, balance unexpended	$4,645.67
June 30, 1898, amount expended during fiscal year	3,217.47
July 1, 1898, balance unexpended	1,428.20
July 1, 1898, outstanding liabilities	332.53
July 1, 1898, balance available	1,095.67
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	14,000.00

Appropriations.

Date.	Amount.	Aggregate.	Date.	Amount.	Aggregate.
May 23, 1828 (survey)	$400.00	$400.00	June 10, 1872	$15,000.00	$306,771.80
March 2, 1829	12,500.00	12,500.00	June 23, 1874	15,000.00	321,771.80
March 3, 1829	15,280.00	27,780.00	March 3, 1875	10,000.00	331,771.80
March 2, 1831	17,450.00	45,230.00	August 14, 1876	5,000.00	336,771.80
February 24, 1832	17,000.00	62,230.00	June 18, 1878	5,000.00	341,771.80
March 2, 1833	15,000.00	77,230.00	March 3, 1879	2,000.00	343,771.80
June 28, 1834	15,000.00	92,230.00	June 14, 1880	3,000.00	346,771.80
March 3, 1835	11,790.00	104,020.00	March 3, 1881	5,000.00	351,771.80
July 2, 1836	12,600.00	116,620.00	August 2, 1882	25,000.00	376,771.80
March 3, 1837	12,000.00	128,620.00	July 5, 1884	10,000.00	386,771.80
July 7, 1838	10,000.00	138,620.00	August 5, 1886	16,875.00	403,646.30
June 11, 1844	5,000.00	143,620.00	August 10, 1888	24,000.00	427,646.80
August 20, 1852	10,000.00	153,620.00	September 19, 1890	10,000.00	437,646.80
June 23, 1866	53,151.80	206,771.80	July 13, 1892	15,000.00	452,646.80
March 2, 1867	80,000.00	286,771.80	August 18, 1894	15,000.00	467,646.80
July 11, 1870	5,000.00	291,771.80	June 3, 1896	8,000.00	475,646.80

COMMERCIAL STATISTICS.

Class of goods.	Net tons.
Coal	53,129
Posts and wood	55
General merchandise	364
Total	53,548

Increase over last year, 17,177 tons; number of passengers carried, 1,546.
Navigation opened May 5 and closed December 2, 1897.

Statement of vessels at Great Sodus Harbor, New York, for the calendar year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home	73	4,849	15	2,023	24	6,462
Foreign	38	2,841	29	6,662	41	13,070
Total	111	7,690	44	8,685	65	19,532
American owned	91	5,988	22	5,764	45	13,304
Canadian owned	20	1,702	23	2,921	20	6,228

Total arrivals, 220; registered tonnage, 35,907.

DEPARTURES.

Home	66	4,269	9	1,729	26	8,328
Foreign	45	3,421	35	6,956	39	11,204
Total	111	7,690	44	8,685	65	19,532

Total departures, 220; registered tonnage, 35,907.

Greatest draft of vessel.....feet.. 13
Greatest tonnage of vessel.....registered tonnage.. 1,080
Greatest load of vessel.....net tons.. 1,176

O O 3.

IMPROVEMENT OF HARBOR AT LITTLE SODUS BAY, NEW YORK.

The improvement has consisted in protecting the harbor by building a breakwater between the bay and Lake Ontario and in deepening the entrance channel by building two jetties and by dredging. The breakwater and jetties consist of cribs of timber ballasted with stone.

A plan of the improvement faces page 2446, report for 1881, and there is a history of the improvement and a description of the bay at pages 3145–3150, report for 1896.

In 1882 the project was adopted to obtain the depth in the entrance channel of 15 feet at low water (zero of the Oswego gauge) by extending the piers a total length of 1,500 feet to the 15-foot curve in the lake and by dredging.

In 1895, 835 feet of this pier extension had been built, and the channel had been dredged to the depth of 15 feet at low water from the bay to the lake with a minimum width of 136 feet.

July 18, 1896, the Chief of Engineers authorized the then available funds to be applied to redredging in maintenance of this channel to the depth of 15 feet and to widen it to 150 feet between the piers and 170 feet through a hardpan shoal toward the outer ends and in advance of them and to necessary repairs to maintain the piers, breakwater, and United States dredge.

Contract was therefore entered into May 27, 1897, with W. J. Daly, of Ogdensburg, N. Y., to redredge this channel to the depth of 15 feet and to increase its width as above. Under this contract there were removed during the fiscal year 26,239.7 cubic yards of sand and gravel and 2,145.2 cubic yards of hardpan and bowlders.

Minor repairs were made to both piers.

Two hundred and forty-one linear feet of the outer end of the east pier requires a new deck, including cap timbers and stringers.

There may be required for expenditure to June 30, 1900, $5,500, as follows:

For redredging	$4,000
For repairs to piers	1,500
Total	5,500

The total commerce of this port during the calendar year ending December 31, 1897, was 68,888 tons. Of this amount 67,950 tons were coal transported by rail from the mines in Sullivan and Luzerne counties, Pa., to Little Sodus, whence, in 1897, 62 per cent was shipped down the St. Lawrence River and 38 per cent to Canadian ports on Lake Ontario.

Little Sodus is in the collection district of Oswego, N. Y.

Money statement.

July 1, 1897, balance unexpended		$9,162.37
June 30, 1898, amount expended during fiscal year		5,407.83
July 1, 1898, balance unexpended		3,754.54
July 1, 1898, outstanding liabilities	$447.84	
July 1, 1898, amount covered by uncompleted contracts	1,850.00	
		2,297.84
July 1, 1898, balance available		1,456.70
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		5,500.00

Appropriations.

Date.	Amount.	Aggregate.	Date.	Amount.	Aggregate.
August 20, 1852	$10,000.00	$10,000.00	August 14, 1876	$5,000.00	$179,441.77
April 9, 1864	1,178.36	11,778.36	June 18, 1878	10,000.00	189,441.77
Do	2,224.00	14,002.36	March 3, 1879	5,000.00	194,441.77
Do	99.00	14,101.36	June 14, 1880	20,000.00	214,441.77
June 23, 1866	33,840.41	47,941.77	March 3, 1881	20,000.00	234,441.77
March 2, 1867	50,000.00	97,941.77	August 2, 1882	25,000.00	259,441.77
April 10, 1869	1,500.00	99,441.77	July 5, 1884	10,000.00	269,441.77
July 11, 1870	5,000.00	104,441.77	August 5, 1886	12,500.00	281,941.77
March 3, 1871	15,000.00	119,441.77	August 10, 1888	16,000.00	297,941.77
June 10, 1872	15,000.00	134,441.77	September 19, 1890	13,000.00	310,941.77
March 3, 1873	15,000.00	149,441.77	July 13, 1892	6,000.00	316,941.77
June 23, 1874	15,000.00	164,441.77	August 18, 1894	8,000.00	324,941.77
March 3, 1875	10,000.00	174,441.77	June 3, 1896	8,000.00	332,941.77

COMMERCIAL STATISTICS.

Class of goods.	Net tons.	Class of goods.	Net tons.
Coal	67,950	Shingles	9
Posts and wood	910		
Fish	11	Total	68,888
Lumber	8		

Increase over last year, 3,470 tons.
Navigation opened April 7 and closed December 20, 1897.

Statement of vessels at Little Sodus Harbor, New York, for the calendar year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home	24	1,490	14	1,800	29	9,206
Foreign	24	3,479	96	13,146	71	26,313
Total	48	4,969	110	14,946	100	35,519
American owned	27	1,664	21	1,390	41	11,755
Canadian owned	21	3,305	89	13,556	59	23,764

Total arrivals, 258; registered tonnage, 55,434.

DEPARTURES.

Home	23	1,462	6	702	19	5,611
Foreign	25	3,507	105	14,252	81	29,908
Total	48	4,969	111	14,954	100	35,519

Total departures, 259; registered tonnage, 55,442.

Greatest draft of vessel ..... feet.. 14
Greatest tonnage of vessel ..... registered tonnage.. 770
Greatest load of vessel ..... net tons.. 887

Appropriations.

Date.	Amount.	Aggregate.	Date.	Amount.	Aggregate.
March 20, 1826	$200.00	$200.00	April 10, 1869, allotment	$22,275.00	$473,362.87
March 2, 1827	33,348.64	33,548.64	Do	6,000.00	479,362.87
May 19, 1828	9,583.39	43,132.03	July 11, 1870	50,000.00	529,362.87
March 3, 1829	7,472.00	50,604.03	March 3, 1871	100,000.00	629,362.87
March 2, 1831	2,812.92	53,416.95	June 10, 1872	100,000.00	729,362.87
Do	18,600.00	72,016.95	March 3, 1873	100,000.00	829,362.87
Do	519.00	72,535.95	June 23, 1874	75,000.00	904,362.87
Do	84.92	72,620.87	March 3, 1875	90,000.00	994,362.87
February 24, 1832	19,000.00	91,620.87	August 14, 1876	90,000.00	1,084,362.87
March 2, 1833	8,400.00	100,020.87	June 18, 1878	90,000.00	1,174,362.87
June 28, 1834	30,000.00	130,020.87	March 3, 1879	90,000.00	1,264,362.87
July 2, 1836	20,000.00	150,020.87	June 14, 1880	90,000.00	1,354,362.87
March 3, 1837	15,000.00	165,020.87	March 3, 1881	50,000.00	1,404,362.87
July 7, 1838	46,067.00	211,087.87	August 2, 1882	80,000.00	1,484,362.87
June 11, 1844	20,000.00	231,087.87	July 5, 1884	80,000.00	1,564,362.87
August 30, 1852	40,000.00	271,087.87	August 6, 1886	71,250.00	1,635,612.87
August, 1860, allotment transferred from light-house	30,000.00	301,087.87	August 10, 1888	100,000.00	1,735,612.87
June 23, 1864, allotment	25,000.00	326,087.87	September 19, 1890	30,000.00	1,765,612.87
June 23, 1866	45,000.00	371,087.87	July 13, 1892	40,000.00	1,805,612.87
March 2, 1867	60,000.00	431,087.87	August 18, 1894	37,000.00	1,842,612.87
July 25, 1868, allotment	20,000.00	451,087.87	June 3, 1896	60,000.00	1,902,612.87

COMMERCIAL STATISTICS.

Class of goods.	Net tons.	Class of goods.	Net tons.
Coal	528,552	Posts and wood	1,481
Lumber	114,426	Fish	41
Grain	44,101	Oil	2
Shingles	6,065	General merchandise	6,787
Poles and railroad ties	2,820		
Laths	2,530	Total	706,805

Passengers carried, 8,918. Decrease since last year, 77,167 tons.
Navigation opened March 27 and closed December 10, 1897.

Statement of vessels at Oswego Harbor, New York, for year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home, on lake	285	95,672	86	19,554	148	53,637
Foreign, on lake	358	83,278	474	89,676	169	52,351
Total	643	178,950	560	109,230	317	105,988
American owned	433	138,393	108	25,656	144	44,746
Canadian owned	210	40,557	452	83,664	173	61,242

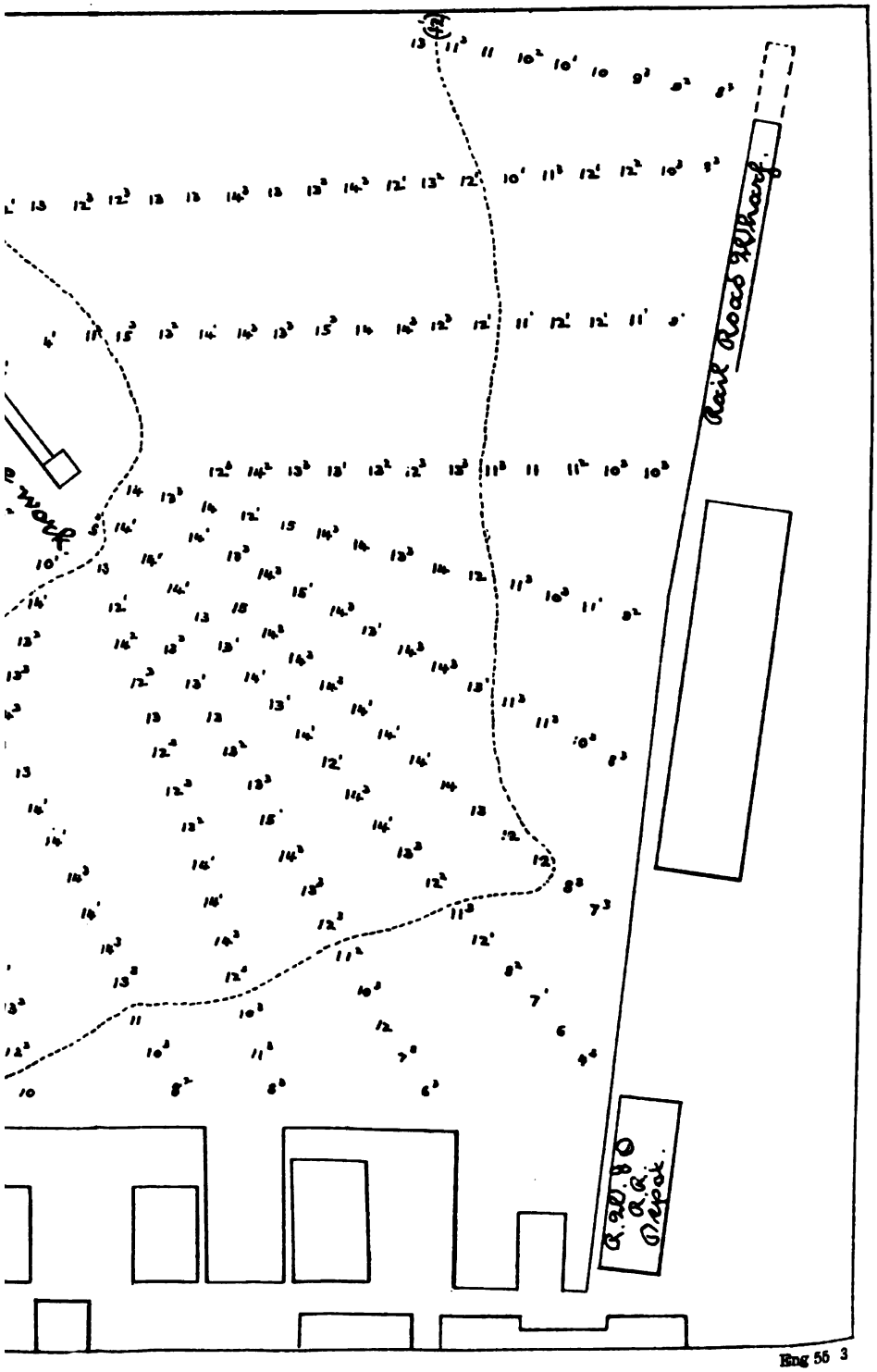
Total arrivals, 1,520; registered tonnage, 394,168.

DEPARTURES.

Home, on lake	311	124,514	113	27,840	34	10,049
Foreign, on lake	333	54,823	444	80,543	283	95,939
Total	644	179,337	557	108,383	317	105,988

Total departures, 1,518; registered tonnage, 393,708.

Total freight carried on canal	tons..	88,572
Increase over last year	tons..	4,144
Greatest draft of vessel	feet..	14
Greatest tonnage of vessel	registered tonnage..	1,565
Greatest load of vessel	net tons..	2,239



Eng 56 3

O O 5.

IMPROVEMENT OF HARBOR AT SACKETTS HARBOR, NEW YORK.

For the history of this improvement see page 3160 of the Report for 96.

During the year an area of about five acres in this harbor, which had en dredged to the depth of 12 feet in 1884, was redredged to that pth by the removal of 23,494 cubic yards of mud, clay, gravel, and wlders by United States plant with direct hire of labor, which, with o stone groins constructed in 1896 to protect from erosion Shiphouse oint, which shelters the harbor, completed the project adopted in 1882 modified in 1896 and 1897.

A cast-iron mooring post was provided and mounted on a crib in the rbor for the use of barges seeking the harbor for refuge during the ter part of the navigation season.

During the year the expenditure has been:

r dredging 23,494 cubic yards, including maintenance of dredge	$2,539.22
r alteration and repair of United States dredging plant (see report of harbor at Great Sodus Bay)	650.00
r one cast-iron mooring post secured in place	35.50
r pay of assistants, office expenses, and surveys	356.99
Total	3,581.71

By authority from the Chief of Engineers of June 24, 1898, this work, er the submission of this report, is to be dropped from the works in arge of this office.

acketts Harbor is in the collection district of Cape Vincent, N. Y.

Money statement.

y 1, 1897, balance unexpended	$3,581.71
ne 30, 1898, amount expended during fiscal year	3,581.71

Appropriations.

Date.	Amount.	Aggregate.
r 20, 1826	$3,000	$3,000
r 23, 1828	3,000	6,000
gust 2, 1882	7,000	13,000
gust 11, 1888	2,000	15,000
gust 18, 1894	5,000	20,000

O O 6.

IMPROVEMENT OF HARBOR AT CAPE VINCENT, NEW YORK.

There has been no change in the status of this improvement since e Report for 1897. For the reason therein stated, page 3286, the commencement of the improvement awaits the further action of Congress.

The expenditures for the year have been:

r inspection and office expenses	$24.29

For a plan of the improvement and the purpose which it will serve e Report for 1897, pages 3286 to 3288.

Cape Vincent is a port of entry.

Money statement.

July 1, 1897, balance unexpended	$24,777.00
June 30, 1898, amount expended during fiscal year	24.29
July 1, 1898, balance unexpended	24,752.71
Amount (estimated) required for completion of existing project	295,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	75,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

COMMERCIAL STATISTICS.

Class of goods.	Tons.	Class of goods.	Tons.
Poles and railroad ties	496	Fish	309
Grain	693	Shingles	501
Hay	510	Iron	33
Lumber	988	General merchandise	1,053
Coal	240		
Posts and wood	1,072	Total	5,885

Decrease since last year, 4.048 tons. Number of passengers carried, 18,641.

Statement of vessels at Cape Vincent, N. Y., for the year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home	161	10,567	33	1,758	5	1,711
Foreign	450	57,898	20	1,134	11	2,693
Total	611	68,465	53	2,892	16	4,404
American owned	182	12,682	34	1,610	10	2,861
Canadian owned	429	55,783	19	1,282	6	1,543

Total arrivals, 680; registered tonnage, 75,761.

DEPARTURES.

Home	166	10,960	31	1,682	10	2,993
Foreign	444	57,414	22	1,210	6	1,411
Total	610	68,374	53	2,892	16	4,404

Total departures, 679; registered tonnage, 75,670.

Greatest draft of vessel	feet..	15
Greatest tonnage of vessel	registered tonnage..	1,550
Greatest load of vessel	net tons..	435

007.

IMPROVEMENT OF SHOALS BETWEEN SISTER ISLANDS AND CROSSOVER LIGHT, AND BETWEEN OGDENSBURG AND THE FOOT OF LAKE ONTARIO, ST. LAWRENCE RIVER, NEW YORK.

The present project for this improvement, as adopted in 1890 and increased in 1896 and 1897, is to remove to the depth of 18 feet below

e zero of the Oswego gauge twelve shoals of rock in or near the track vessels between Sister Islands light and the head of Brockville Narws, a distance of 11 miles. Their location is shown on the sheet that ces page 3292 of the Report for 1897. Seven of these shoals, D, E, F, H, J, and L (see page 3290, Report for 1897, and sheet above mened), were, prior to this fiscal year, excavated to the depth of 16½ feet low the zero of the Oswego gauge, but for the reasons fully stated in e Report for 1897 (p. 3291), the Chief of Engineers, April 13, 1897, thorized the removal of Dark Island Shoal (K) and Blind Bay Shoal) to a depth greater by 1.4 feet—i. e., to 18 feet below the zero of the wego gauge. He further authorized an estimate of the cost of noving all the twelve shoals to that increased depth—18 feet below e zero of the Oswego gauge—with a statement of the necessity for ch increased depth, to be submitted in the Annual Report for his conleration in connection with section 4 of the river and harbor act of ne 6, 1896. Such statement of the necessity for that increase in pth will be found on the page above cited (3291), Report for 1897.

During the fiscal year Dark Island Shoal (K) and Blind Bay Shoal) have been wholly removed to the latter depth by the excavation of 112 cubic yards from the former and 150 cubic yards from the latter; tal, 3,562 cubic yards. This excavation was made by Mr. W. J. Daly, Ogdensburg, N. Y., under written proposal and written acceptance, $7.25 per cubic yard, Mr. Daly's proposal of $7.50 per cubic yard in sponse to thirty days' advertisement having been rejected.

In February and March, 1898, Shoals D, E, F, H, and J were surveyed m the ice by Assistant Engineer John C. Churchill, jr. A, C, and L, th the spur near it, could not be so surveyed, as the ice did not form ar them. To complete the project, 6,523 cubic yards of rock remain be excavated, as follows:

Cubic yards to be excavated.

dge A	3,350
B	686
C	120
D	102
E	98
F	60
H	33
J	100
L	250
M	1,724
Total	6,523

The expenditures during the year have been:

r excavating 3,562 cubic yards of rock (less $87.92 deducted for pay of nspector)	$25,736.58
r pay of assistant, surveys, office expenses, printing, and advertising.	926.35
Total	26,662.93

These ledges are in the track of vessels which carry nearly the entire mmerce of the St. Lawrence River, amounting to about 1,200,000 tons nually, three-fourths of which, it is estimated, are carried in American ssels.

The estimated cost of completing the removal of all these ledges to e depth of 18 feet below the zero of the Oswego gauge is $60,000.

Money statement.

July 1, 1897, balance unexpended	$26,914.23
June 30, 1898, amount expended during fiscal year	26,666.73
July 1, 1898, balance unexpended	247.50
Amount (estimated) required for completion of existing project	60,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	60,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Date.	Amount.	Aggregate.
Act of—		
September 19, 1890	$5,000.00	$5,000.00
July 13, 1892	10,000.00	15,000.00
August 18, 1894	8,000.00	23,000.00
June 3, 1896	25,000.00	48,000.00

OO 8.

IMPROVEMENT OF HARBOR AT OGDENSBURG, NEW YORK.

The project for this improvement, adopted in 1890 and modified in 1897, is, by dredging, to deepen to 15 feet below the zero of the Oswego gauge the channel, 1⅞ miles in length, along the front of Ogdensburg, on the St. Lawrence and Oswegatchie rivers, and the entrance channel to the Oswegatchie; and to 16 feet the two lower entrance channels from the St. Lawrence. During the fiscal year, under contract with Mr. W. J. Daly, of Ogdensburg, N. Y., made April 16 and approved May 1, 1897, 107,621 cubic yards of sand, silt, and mud, with some hardpan and bowlders, were dredged to October 8, 1897, when the contract was completed. Under this contract the depth prescribed in the project was obtained in the three entrance channels and along 1,100 feet of the wharfage front.

The channel, 900 feet in length, next above Franklin street, is used only for occasional communication between the Oswegatchie and the lower harbor by boats of lighter draft, and is continually shoaling from discharge by sewers. The depth requisite there is not more than 14 feet.

This requirement as to depth is here presented by authority from the Chief of Engineers of February 27, 1897.

The expenditures for the year have been:

For dredging	$16,402.39
For pay of assistant and inspector, surveys, and office expenses	1,560.82
Total	17,963.21

Ogdensburg is in the collection district of Oswegatchie, N. Y.

Money statement.

July 1, 1897, balance unexpended	$18,112.16
June 30, 1898, amount expended during fiscal year	17,963.34
July 1, 1898, balance unexpended	148.82
Amount (estimated) required for completion of existing project	37,944.44
Amount that can be profitably expended in fiscal year ending June 30, 1900	24,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations and allotments.

Date.	Amount.	Aggregate.	Date.	Amount.	Aggregate.
August 30, 1852	$3,000.00	$3,000.00	July 28, 1880 (from appropriation for "examinations, surveys, and contingencies of rivers and harbors")	$50.00	$110,355 56
March 2, 1867	40,000.00	43,000.00	August 2, 1882	10,000.00	12 ,355 56
July 11, 1870	15,000.00	58,000.00	July 5, 1884	15,000.00	135,355.56
March 3, 1871	25,000.00	83,000.00	August 5, 1886	10,000.00	145,355.56
June 10, 1872	10,000.00	93,000.00	August 11, 1888	15,000.00	160,355.56
March 3, 1873	6,000.00	99,000.00	September 19, 1890	42,000.00	202,355.56
June 23, 1874	6,000.00	105,000.00	July 13, 1892	40,000.00	242,355.56
March 3, 1875	5,000.00	110,000.00	August 18, 1894	20,000.00	262,355.56
December 11, 1877 (from appropriation for "repairs of harbors on northern lakes")	5.56	110,005.56	June 3, 1896	20,000.00	282,355.56
September 10, 1879 (from appropriation for "examinations, surveys, and contingencies of rivers and harbors")	300.00	110,305.56			

COMMERCIAL STATISTICS.

Class of goods.	Net tons.	Class of goods.	Net tons.
Grain	412,883	Wood pulp	470
Coal	162,929	Hay	403
Lumber	162,218	Poles and railroad ties	237
Nickel matte	12,334	Fertilizers	159
Lath	8,847	Posts and wood	84
Shingles	6,059	Oil	74
Hides	873	General merchandise	95,519
Iron	2,271		
Raw silk	675	Total	866,035

Decrease since last year 20,403 tons; passengers carried, 50,050.

Total duties collected	$75,870.86
Total fees collected	314.30
Value of imports	5,984,439.00
Value of exports	4,860,755.00
Value of merchandise entered for warehouse and transshipped in bond	24,936.00
Value of merchandise entered for transshipment and export	214,709.00
Amount of duties on above	47,469.59
Value of merchandise entered for immediate transportation without appraisement (5,269 packages)	405,921.00
Estimated duty on above	2,197.13

Merchandise received under consular seal from foreign ports, 1897.

Class of goods.	Packages.	Value.
	Number.	
Matting	20,659	$77,692.00
Silk goods	1,375	923,477.00
Tea	27,775	273,959.00
Chinese groceries	8,598	20,870.00
Straw braid	3,076	139,671.00
Curios	3,674	207,043.00
Wool	2,473	133,257.00
Matte	11,888	225,413.00
Miscellaneous	10,136	334,200.00

Statement of vessels at Ogdensburg Harbor, New York, during the year ending December 31, 1897.

ARRIVALS.

Trade engaged in.	Steamers.		Sailing vessels.		Barges.	
	Number.	Registered tonnage.	Number.	Registered tonnage.	Number.	Registered tonnage.
Home	784	334,855	56	27,244	62	14,825
Foreign	617	63,124	14	4,294	405	143,973
Total	1,401	397,979	70	31,538	467	158,798
American owned	1,048	377,875	63	29,655	152	45,260
Canadian owned	353	20,104	7	1,883	315	113,538

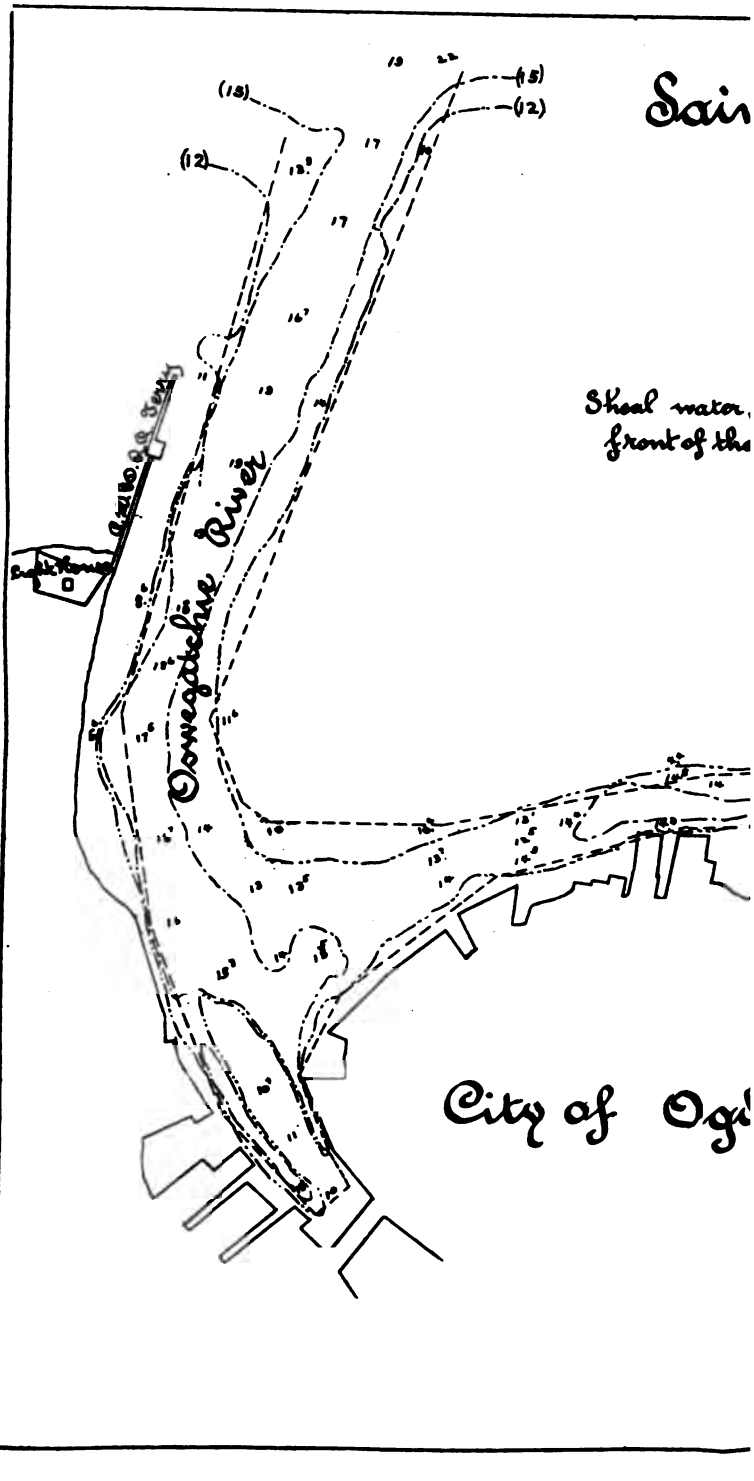
Total arrivals, 1,938; registered tonnage, 588,315.

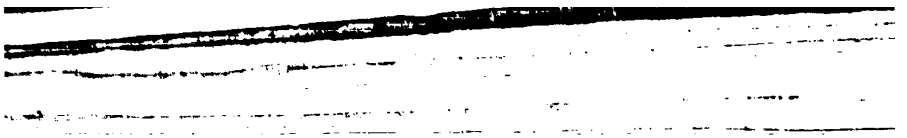
DEPARTURES.

Home	813	338,854	65	30,449	203	70,941
Foreign	584	56,750	8	2,040	256	85,672
Total	1,397	395,604	73	32,489	459	156,613

Total departures, 1,929; registered tonnage, 584,706.

Greatest draft of vessel ..... feet.. 16
Greatest tonnage of vessel ..... registered tonnage.. 1,565
Greatest load of vessel ..... net tons.. 2,867


Sain
(15)
(12)
(15)
(12)
Shoal water
front of the
Connecticut River
City of Og



APPENDIX P P.

EXAMINATION OF RESERVOIR SITES IN WYOMING AND COLORADO.

REPORT OF LIEUT. COL. HIRAM M. CHITTENDEN, U. S. VOLUNTEERS, CAPTAIN, CORPS OF ENGINEERS.

[Printed in House Doc. No. 141, Fifty-fifth Congress, second session.]

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 6, 1897.

SIR: The river and harbor act of June 3, 1896, provides in section 8 for a number of preliminary examinations, among which is the following:

> For the examination of sites, and report upon the practicability and desirability of constructing reservoirs and other hydraulic works necessary for the storage and utilization of water, to prevent floods and overflows, erosion of river banks and breaks of levees, and to reenforce the flow of streams during drought and low-water seasons, at least one site each in the States of Wyoming and Colorado.

The examination thus provided for has been made by Capt. Hiram M. Chittenden, Corps of Engineers, and I have now the honor to submit that officer's report of November 6, 1897, on the subject. Captain Chittenden entered upon this duty with zeal and with more than ordinary personal interest, and his very admirable report shows deep research and a close study of the subject in hand, involving the examination of a vast amount of data and of territory of wide extent. This paper is accompanied by 13 maps and diagrams and 26 photographs, and in view of the importance of the subject under consideration and the interest manifest by those to be most deeply affected by the establishment of these reservoirs, if constructed, I beg to recommend that all the accompanying papers be printed.

Captain Chittenden's report was transmitted to this office by Lieut. Col. Amos Stickney, Corps of Engineers, who has had large experience

in connection with Western rivers, and attention is invited to his remarks touching the construction of these reservoirs.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

LETTER OF LIEUT. COL. AMOS STICKNEY, CORPS OF ENGINEERS.

ST. LOUIS, MO., *November 13, 1897.*

GENERAL: I have the honor to submit the following report upon the examination of reservoir sites in Wyoming and Colorado, directed by act of Congress of June 3, 1896, and assigned to my charge by letter from your office of August 1, 1896, with the view of having it carried out by Capt. H. M. Chittenden, Corps of Engineers:

In conformity with the above Captain Chittenden was directed to make the examinations, and he has performed the duty as thoroughly as possible with the funds allotted for the purpose, viz, $5,000 from the contingent appropriation. He has made many personal examinations, and collected a large amount of valuable data from surveys and various sources.

His report, transmitted herewith, gives much information upon the subject investigated, and it is hoped furnishes the information contemplated by the act of Congress and instructions from your office. I concur generally in the conclusions reached by Captain Chittenden from the study and data set forth in his report. There are a few points to which I would invite attention. In the estimates of cost of work some of the units of price may have been taken too low, especially if work is contemplated under the laws and regulations governing hours of labor and manner of conducting Government work. The items for contingencies, in estimates based upon general examinations and limited preliminary surveys in a rough country, should be larger than what might be considered ample in localities where labor and supplies can be more quickly and easily obtained, and the work of a character and extent to be closely estimated. Captain Chittenden believes his estimates to be ample, and reference is made to them only as a matter of caution.

Special attention is invited to the conclusions relating to the purposes to be served by the construction of reservoirs. First and far above other reasons for their construction is their adaptability and value for industrial purposes; for irrigation of land, furnishing power, and for water supply for cities, and in this way adding greatly to the material prosperity and progress of parts of the country which, without such assistance, would be almost valueless and might remain almost uninhabited. As to their effect upon the flood conditions and low-water navigation of the larger rivers, it may be said to be comparatively small and only beneficial to any considerable degree by an enormous expansion of the system.

The question of the propriety of the National Government entering upon the work of reservoir construction in the arid regions is one of public policy which, it is believed, should be left for the consideration of Congress upon the facts presented. The construction of any one reservoir would of course affect only a limited region of country, but the effect of a system of reservoirs built wherever the conditions were

favorable might be far-reaching, and not only add largely to the welfare of communities in their immediate vicinity, but indirectly affect many others.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Lieutenant-Colonel of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

LETTER OF CAPT. HIRAM M. CHITTENDEN, CORPS OF ENGINEERS.

ST. LOUIS, MO., *November 6, 1897.*

COLONEL: I have the honor to submit herewith a report upon the examination of reservoir sites in Wyoming and Colorado, directed by act of Congress of June 3, 1896.

Very respectfully, your obedient servant,

HIRAM M. CHITTENDEN,
Captain of Engineers.

Lieut. Col. AMOS STICKNEY,
Corps of Engineers, U. S. A.

REPORT OF CAPT. HIRAM M. CHITTENDEN, CORPS OF ENGINEERS, UPON EXAMINATION OF RESERVOIR SITES IN WYOMING AND COLORADO, UNDER THE PROVISIONS OF ACT OF CONGRESS OF JUNE 3, 1896.

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I.—PRELIMINARY CORRESPONDENCE AND STATEMENT.

The following correspondence and statement explain the origin and scope of the investigations treated of in this report:

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 1, 1896.

COLONEL: The river and harbor act of June 3, 1896, provides for a preliminary examination as follows:

"For the examination of sites and report upon the practicability and desirability of constructing reservoirs and other hydraulic works necessary for the storage and utilization of water, to prevent floods and overflows, erosion of river banks and breaks of levees, and to reenforce the flow of streams during drought and low-water seasons, at least one site, each, in the States of Wyoming and Colorado."

In this connection your attention is invited to the accompanying copy of a letter, dated the 28th ultimo, from this office to the Secretary of War, and to War Department indorsement thereon.

The examination is assigned to you, with a view to having it carried out by Captain Chittenden at such time as his other duties will permit.

Very respectfully, your obedient servant,

A. MACKENZIE,
Acting Chief of Engineers.

Lieut. Col. AMOS STICKNEY,
Corps of Engineers.

*Not reprinted. Printed in House Doc. No. 141, Fifty-fifth Congress, second session.

In the letter from the Chief of Engineers to the Secretary of War, referred to above occurs, the following:

It appears practicable to allot $5,000 from the appropriation for contingencies of rivers and harbors for the second item (examination of reservoir sites), and for such a sum it is believed that a sufficient amount of information can be secured to permit of presenting to Congress a report on the subject which will give at least some of the information sought. I therefore recommend that as extensive an examination of reservoir sites in Wyoming and Colorado be made as can be done with an expenditure of not to exceed $5,000, and the results of such work be presented to Congress as a report on a preliminary examination, together with estimates of the cost of such surveys as will permit a full compliance with the requirements of the act.

This recommendation was approved by the Secretary of War July 30, 1896.

Under date of August 7 the above correspondence was transmitted to me, with a letter calling for a project for the expenditure of the allotment of $5,000. On the same date I submitted a project, of which the following were the essential features:

(1) A personal examination of eligible sites for reservoirs in the section in question, with such preliminary surveys as will give the necessary data as to capacity, cost, watershed, and the extent of country and nature of industries to be benefited by their construction.
(2) The collection of data from all available sources relating to reservoirs, their cost, influence on streams below them, utility in various lines, etc.
(3) The preparation of a map designed to show the general surface features of the Western country, the location of possible reservoir sites, and all other matters necessary to elucidate the report.

This project was transmitted, with your letter of August 8, to the Chief of Engineers and by him approved on the 12th of the same month.

CHARACTER OF WORK.

The item in the river and harbor act directing this investigation was not clear as to the character and extent of the work contemplated by it. In his letter to the Secretary of War, from which an extract is given above, the Chief of Engineers says:

It will be noted that while these are ordered as preliminary examinations (not discretionary), the definite and detailed information called for gives them the character of a survey rather than a preliminary examination.

And again, in the same letter, the Chief of Engineers recommends "that as extensive an examination of reservoir sites in Wyoming and Colorado be made as can be done with an expenditure of not to exceed $5,000."

It was accordingly assumed that the character of work to be done was controlled rather by the amount of funds available than by the heading in the river and harbor bill under which the appropriation occurs. The project was prepared with this view and received the approval of the Chief of Engineers, and the work under it has been carried out in accordance therewith. It will be found in the following report that, as to most of the reservoir sites considered, the information presented is sufficiently complete to obviate the necessity of further surveys other than those which naturally accompany the work of actual construction. The data collected are sufficient in detail to form a basis for immediate appropriation for construction should the work, from other points of view, be deemed worthy of Government adoption. For this reason no estimate is submitted for further surveys of these sites.

There were examined in all two reservoir systems in Colorado and three in Wyoming, while several others have received casual inspection or have been brought to my attention closely enough to indicate that they will in time become meritorious projects. In Wyoming the three sites

are on the Laramie, Sweetwater, and Big Piney rivers, respectively, in the southern, central, and northern portions of the State. The first two were carefully surveyed by Mr. F. B. Maltby, United States assistant engineer, in May and June of the present year. The Big Piney system, which really comprehends three sites, has been surveyed by Mr. Fred Bond, of Buffalo, Wyo. The Colorado sites are located one on the South Fork of the South Platte River and the other near Loveland, Colo., between the Big Thompson and Cache à la Poudre rivers, in what are known as the Boyd Lakes. These sites were surveyed by Mr. Maltby in May, June, and July of the present year. The reports of Messrs. Maltby and Bond are submitted herewith. (Appendixes A and B.)

In addition to the field work upon these several sites, I have personally given considerable attention to the various localities interested in the work. In December, 1896, I attended the meetings of the American Society of Irrigation Engineers and of the Irrigation Congress, held respectively in the cities of Denver, Colo., and Phœnix, Ariz. I also visited several of the existing reservoirs in California and some in process of building. In May of the present year I visited the South Platte site in Colorado and the Laramie and Sweetwater sites in Wyoming. In August and September I traveled through a large section of Wyoming and a small part of northeastern Colorado for the purpose of learning as much as possible about the needs and facilities for the storage of water in these States. Wherever I have been I have received valuable assistance from various parties, particularly from the State engineers of Colorado and Wyoming, and am under considerable obligations therefor. On my Wyoming trip I was accompanied by Prof. Elwood Mead, State engineer, whose thorough acquaintance with all the features of the subject I was studying was of great value to me. Professor Carpenter, of the Colorado State Agricultural College, has likewise rendered valuable assistance, as have Mr. Horace A. Sumner, ex-State engineer of Colorado; Mr. J. D. Schuyler, of Los Angeles, Cal., and Mr. F. H. Newell, of the United States Geological Survey.

Besides Messrs. Maltby, Seddon, and Bond, elsewhere mentioned, the employees who have been mainly instrumental in helping to prepare this report are Messrs. A. H. Blaisdell, E. D. Williams, and S. F. Crecelius, assistant engineers; Messrs. V. Schindler, E. Kuhl, and J. F. Deppe, draftsmen; Mr. W. L. Lohmann, clerk; and Mrs. Laura S. Green, copyist.

As my investigations have proceeded it has become evident that, as to a portion at least of the objects mentioned in the bill, the project of building reservoirs in the arid regions of this country is a practicable one, while from industrial and commercial considerations it is eminently desirable. The real matter in doubt seemed to be not so much the importance of these works in themselves as the advisability of their construction by the General Government. To this feature of the question I have given most careful consideration, with the earnest desire to present it in all its bearings, favorable as well as unfavorable. It is a new departure, and while the works themselves will be of great public utility, it may yet not be apparent that the Federal Government is the proper agency to undertake them. If my investigations have resulted more favorably than might have been expected to the policy of Government patronage of these great works, I trust that I have at every step supported my conclusions with substantial facts.

The report embraces—

(1) Some remarks upon the varieties of reservoir sites to be found in the arid regions and upon the various methods of dam construction practiced there.

(2) A description of the several sites examined and of the works proposed, together with special reports by the assistants who executed the work.

(3) A general discussion of the subject of reservoirs, with illustrations drawn from natural and artificial systems in various parts of the world.

(4) The influence of reservoirs upon floods, with an exhaustive monograph upon the floods of the Mississippi River and its tributaries, by Mr. James A. Seddon, United States assistant engineer.

(5) The uses of reservoirs for irrigation and other industrial purposes.

(6) The proper agency to construct reservoirs in the arid regions—private individuals, corporations, irrigation districts, the States, or the General Government.

(7) The magnitude and ultimate cost of a complete storage system for the streams of the arid regions.

(8) A condensed résumé of the whole subject.

II.—GENERAL REMARKS ON RESERVOIR SITES IN THE ARID REGIONS.

The several reservoir sites considered in this report present all the varieties which are liable to be met with anywhere in the West. These may be grouped under three heads: (1) Open valleys on the courses of streams, (2) natural lakes, and (3) natural depressions without outlets.

Reservoir sites of the first class occur in greater numbers than either of the others. They may be found in greater or less perfection upon almost every stream, and in some instances present admirable opportunities for the inexpensive storage of water. Ordinarily they are simple expansions of the immediate valleys of streams, giving considerable areas but slightly elevated above the water surface. Nearly always in such places the streams have gentler slopes than either above or below, often passing from a torrential to a placid condition, only to return to their impetuous course as soon as the open valleys are passed. These expanded tracts are generally closed in at the lower ends by bluffs of considerable height, and frequently by precipitous hills, between which the streams flow in rocky chasms. In these narrow gorges are found the best sites for cutting off the flow of the streams and storing it in the open valleys above.

It will at once be seen that the most favorable site of this class, so far as capacity for storage is concerned, will be that which combines a broad open valley, a gentle slope to the stream, and a very narrow outlet, where an inexpensive dam of moderate height will give the required capacity. In the Sweetwater site, presently to be described, is one of the most perfect examples to be found in nature.

Reservoirs of large area have one drawback as compared with those of less area and the same capacity, and that is the greater loss by evaporation. But this drawback is more than compensated by the greater cheapness of storage. In fact, to secure large capacity in confined sites requires such high and massive structures as to be almost prohibited by the cost. The relative advantages of the two can readily be seen by comparing the statistics of the Sweetwater and South Platte sites, described below. Besides the two sites just mentioned, the Piney site in Wyoming falls under this class.

Reservoirs of the second class, viz, natural lakes, though of less frequent occurrence than those just described, are the most advantageous sites for the storage of water that can be found. In the case of the open valley site, the storage gained for a considerable height of

dam above the datum (taken at low-water surface of stream at site of dam) is very small. Often the first 30 or 40 feet give comparatively insignificant results, although this part of the structure must be the most thorough and expensive of all. The site on the South Platte illustrates this drawback. In the case of a natural lake, on the other hand, every foot which the dam rises above the datum (the lake surface, if the dam is at the outlet) gives a storage computed upon the entire area of the lake. To cite a prominent example, a rise of 1 foot in the surface of the Yellowstone Lake, whose area is 139 square miles, would represent nearly 4,000,000,000 cubic feet (92,000 acre-feet) of water. Another great advantage of such a site is that evaporation from the reservoir will not be much greater than that from the lake in its natural condition, and the computed flow of the stream may, therefore, all be counted in storage. The lake site is also free from the objection to the open valley sites which arises from periodical drainage of the reservoir; for even if the storage water be entirely drawn out, the natural lake is still there, and the unsightly spectacle and possible unhealthiness of an empty reservoir are avoided. This drawback to open valley sites, however, can in some degree be obviated by giving the reservoir a capacity considerably in excess of the actual needs for storage. It will not then be necessary to drain the reservoir entirely, and it will acquire the character of a permanent body of water.

The largest artificial reservoirs in the world, and the most inexpensive storage, are found in these lakes where the natural surface has been raised by low dams at the outlets. The principal examples are those on the Volga and Msta rivers in Russia and on the head waters of the Mississippi in the United States.

The third class of reservoir sites consists of natural depressions in the general surface of the country, into which the water of neighboring streams can be conveyed through artificial canals. The occurrence of these depressions is quite common throughout the arid regions, probably more so than is generally supposed. Hitherto there have been no special reasons for noting their existence; but now that they are seen to have an important economic value, their actual number will doubtless be found to be very great. They will form an important element in the future storage system of the Western streams, and their great number and general distribution must be considered a most fortunate provision of nature.

Of the causes that have produced these singular formations it is not essential to the purposes of this report to speak. It is sufficient to know that in the considerable number of examples already made use of in the storage of water they have proven to be the most compact and impervious of dams.* In the matter of safety, all possibility of breakage is removed, for the thickness of the rim is so great as to make an absolutely immovable resistance to the body of water behind it.

These depressions, or basins, as they are commonly called, are in some cases entirely dry, and in others occupied by lakes, the watershed of the basin being insufficient to fill them to overflowing. The great

*As an interesting example, we may cite a reservoir of the Wyoming Development Company, near Wheatland, Wyo.; area, 384 acres; depth, 40 feet. When the reservoir was first filled, the inflow was shut off and it was allowed to stand for a period of thirty-eight days. In that time it fell 14 inches. As this was in midsummer, at least 10 inches of the loss was due to evaporation, and possibly more. During this time work on the outlet tunnel was going on and the cut extended to within 20 feet of the water's edge. The ground in the cut was perfectly dry, showing no signs of infiltration from the reservoir.

Laramie basin, one of the Wyoming sites, is practically dry, there being only two or three small ponds in the bottom. The Lake De Smet site, in Wyoming, and the Loveland site, in Colorado, are examples of natural depressions partly filled with water.

The great drawbacks to this class of reservoirs are the difficulty and expense of getting water into and out of them. To be effective, a reservoir must store the flood waters of a stream, for it is in periods of flood that the great waste of streams in their natural state occurs. Unless this waste can be prevented the reservoir does not accomplish its purpose. Reservoirs of the first and second classes, lying directly in the valleys of streams, absolutely cut off all flow until they are full. But with reservoirs of the class now under consideration, their ability to conserve the flood flow is limited to the capacity of the feeders or inlet canals. Of necessity these must be capable of carrying the flood discharge of the stream or a large amount of storage is sure to be lost. The cross section of the feeder will therefore be out of all proportion in size to the mean quantity of water conveyed through it, and will necessarily be an expensive feature of the project.

The outlet, likewise, will generally cost more than in ordinary reservoirs. The tunnel or cut required to carry the water through the rim of the reservoir will almost invariably be of much greater length than a reservoir of either of the other classes would require, and will be correspondingly more costly.

It will thus result in the average case that, notwithstanding the absence of artificial dams, reservoirs of this class will be rather expensive. The cost per acre-foot of water stored will probably fall below that of the open valley sites, but will be greater than that of the lake sites.

One feature of great importance pertaining to these basins is the fact that they occur most frequently below the mountains, either among the foothills or out upon the plains. They are thus well designed to supplement the reservoirs located higher on the streams, and to aid in collecting the storm waters and sudden freshets which so frequently occur in the foothills.

The only condition of serious importance pertaining to reservoir construction in the Western country, not exemplified in some of the sites chosen, is the rapid deposition of sediment characteristic of some of the streams. There are many streams, for example, in the southern section of the country, as on the Gila River, where the amount of material carried in flood is so great that it would rapidly destroy the largest of artificial reservoirs, unless some method were devised to get rid of it. Fortunately none of the sites here considered is liable to this difficulty. The South Fork of the South Platte River, at the site of the dam, affords no evidence of carrying a very large amount of sediment. I saw the Laramie River at high water, near the point where it is proposed to take its waters for storage. It was comparatively clear, and certainly carried no amount of sediment that could seriously affect the capacity of a large reservoir. Piney Creek is a crystal mountain stream, and I doubt if in highest stages its waters are laden with much sediment. The Sweetwater River seemed to me the only one which need cause any concern on this account. That stream evidently washes down considerable sand, but sand is too heavy a material to be carried far in suspension, except by a strong current. It would be almost all of it deposited immediately upon the entrance of the stream to still-water and would not spread itself over the general area of the reser-

voir. If the accumulation should be found injurious, or liable seriously to encroach upon the capacity of the reservoir, it would not be a difficult or expensive matter to provide means for washing it away.

There is still another class of reservoirs of great economic importance, which will not, however, be considered in this report. These are small basins designed to collect the waters from wind-mill pumps, artesian wells, springs, and local storms. They are usually intended to serve only single farms, or portions of them, and come more properly under the head of distributing works. They so obviously pertain exclusively to private enterprise that their consideration does not properly fall within the scope of this report.

III.—DAM CONSTRUCTION.

The reservoir sites considered in this report likewise present opportunities for all the varieties of dam construction practiced in America, excepting wooden structures. These may be broadly divided into three general classes, which, however, blend into one another and are subject to a great variety of modifications—masonry dams, loose rock or rock-fill dams, and earthen dams.

Masonry dams stand first in popular favor as the safest structures of their kind. Experience confirms this popular view, as there have probably been fewer failures of masonry dams, in proportion to the number built, than of either loose rock or earthen dams. While it is certainly not true that the masonry structure is best suited to every site, and probably not true that it is always safest, still its appearance conveys to the average mind an impression of stability not possessed by any other form of dam.

The insuperable obstacle to the very general application of this form of structure is its great cost. It is, therefore, generally restricted to narrow sites, where the quantities may be reduced to a minimum.

Masonry dams are particularly well adapted to rock foundations and to those sites where it is important that the outlet works shall be carried through the dam itself. With earth it is well-nigh impossible to secure such a close contact with rock, wood, iron, or any other hard material that water, under pressure, will not find a route along the joint.

Masonry is not so well adapted to soft foundations as other forms of structure, which can settle and follow up any yielding to pressure. Cribs filled with rock make excellent dams where masonry would probably fail. If masonry is used in such places, it would have to rest on pile foundations, and the problem of cutting off the underflow would have to be considered separately from the construction of the dam proper.

It may, therefore, be taken as a rule that the masonry dam is generally limited to narrow chasms through solid rock, for here alone can the conditions be found that develop to the utmost the merits of the dam.

The question as to whether the axis of the dam should be straight or curved has been much discussed. The main argument for the curved form is, of course, the additional strength which the arch secures. It is urged that, even if the arch action is not ordinarily brought into play, it is a great factor of safety against extraordinary causes of rupture, such as earthquakes, for any motion in the structure produced by the pressure behind it would tend to consolidate it. Again, it is usually found that the curved form lends itself better to the accidents of the

Lake Hemet Dam Now 110 ft high. View from below showing Stairways, water gates, Pelton water wheel &c.
Parks Dam 94 ft.
Located in Riverside Co. Cal.
F.H. Maude photo.

LAKE HEMET (CAL.) MASONRY DAM

LAKE HEMET (CAL.) MASONRY DAM.

ground and is better adapted than the straight form to secure a good hold upon the walls of the chasm.

Against the curved form it is urged that such a structure is not adapted to develop the strength of the arch. For this purpose there must be a slight motion to the structure; but in the dam this motion is prevented by the immovable bond between the base of the dam and the foundation.

It is also urged that the argument of economy resulting from the smaller amount of material required in the arch form than for the gravity profile will not hold good for long dams. Assuming the same limit of crushing resistance that controls the gravity profile, the strains produced in the extremities of a long arch dam would require a greater cross section of masonry than those in the simple straight form.

While the latter argument is probably sound, the first has been effectually refuted by the results of actual experience. Not to mention the slender profile of the Zola Dam in France, it will be enough to cite the celebrated instance of the Bear Valley Dam in California. The profile of the dam resembles a section of a square column resting upon a pedestal, only that one side of the column is vertical and the other slightly inclined. The section has a breadth of 8.5 feet at the base and only 3 feet at the top, 48 feet above the base. The line of resultant pressure when the dam is full falls outside the base, and the stability of the structure is thus absolutely dependent on the arched form. This structure is destined to an enviable distinction in the history of engineering works. The boldness and apparent hazard involved in its construction denote a confidence on the part of the man who designed it in the application of mechanical principles which is not often exemplified even in the engineering profession. The dam has been the marvel of engineers, who have long predicted its early failure only to see their predictions fail instead. The dam has now stood successfully for thirteen years. It has been of immense service to the engineering profession in that it has demonstrated that the arch principle may be effective in dams, notwithstanding the immovableness of the bottom of the structure. It is doubtful, however, if the example will be of much importance in leading to imitation in future works. Engineers, while admitting the practical value of the arch form in dam construction, will still be unwilling to brave popular prejudice against structures of such apparent weakness. The perils of reservoir accidents are so great and appalling that it is desirable to avoid even the appearance of weakness. Generally, therefore, we may expect that engineers, while using the curved form in order to realize whatever advantages it offers, will at the same time build on the gravity profile. This double source of stability ought naturally to inspire the greatest confidence in the permanence of a well-built masonry dam.

Either rock or concrete may be used in the construction of these dams. The rock may be coursed masonry with joints laid in mortar or irregular rubble with a large percentage of concrete. The latter method is probably best in that it avoids regular joints through the masonry. It is at the same time much less expensive.

The rock-fill dam, as its name implies, consists in filling the site where it is placed with loose rock in sufficient quantity to give the necessary stability against pressure from the water behind it. As the rock is thrown in loose and without other arrangement than that which it assumes on falling into place, the cost per yard is very much less than that of regular masonry; so much less that, after taking into account the greater quantity required, the structure is ordinarily much

less costly than a masonry dam in the same place. Economy of expenditure, therefore, commends it wherever other conditions will permit its use.

This form of dam can be made perfectly safe for heights of 150 feet at least, provided care is taken to provide an ample spillway entirely around the dam. It is not a safe structure if liable to be overtopped by any considerable depth of water.

Various methods have been resorted to to secure an impervious condition in rock-fill dams. In streams carrying much sediment, the deposition among the voids of the structure can be counted on to close it up ultimately. But with clear mountain streams this resource could not be relied upon. A common method is that of facing the upper slope of the dam with a wooden sheeting, designed to be water-tight. The Escondido Dam in California, of which the accompanying cuts are illustrations, is a good example. The dam is 76 feet high, 100 feet long on the bottom, 390 feet long on top, 100 feet thick at base, and 10 feet thick at top. The slope on the upper face is 1 on ½; on the upper half of the lower face it is 1 on 1, and on the lower half, 1 on 1¼. The structure was built of clean rock in sizes running up to 4 tons in weight. The quantity used was 37,159 cubic yards. Of this 6,000 yards was laid up carefully as dry rubble on the upper face, the thickness of this rubble wall being 5 feet at the top and 15 feet at the bottom.

The soil was cleared from the entire base of the dam and the rock placed directly thereon. At the upper toe a trench was dug of varying depths up to 12 feet and filled with rubble masonry laid in Portland-cement mortar. This wall forms the connection between the timber facing of the dam and the bed rock.

The timber facing rests against the rubble face of the rock fill. The supporting timbers for the sheeting are 6 inches square and are buried 4 inches in the rubble face. On these were spiked the sheeting plank in two layers, the plank varying in thickness from 3 inches at the bottom to 1½ inches at the top. The 2-inch space between this sheeting and the rubble wall is filled with concrete to give full bearing to the sheeting throughout.

Under the pressure of the water and the natural action of time the dam has settled slightly. I am informed by Mr. E. F. Tabor, engineer of the work, that prior to the high water of the present year the settlement in the rock fill had been 0.4 foot, and that it had settled an additional 0.17 foot as a result of the last high water, which completely filled the reservoir.

The Escondido Dam is a fair type of this class of structure. The most important variation from it in other dams consists in the method of securing the water-tight surface. Concrete is not a good material on account of the certainty of its cracking with the settlement of the dam. Asphalt has been used, and its elastic qualities would seem to be admirably adapted to this purpose.

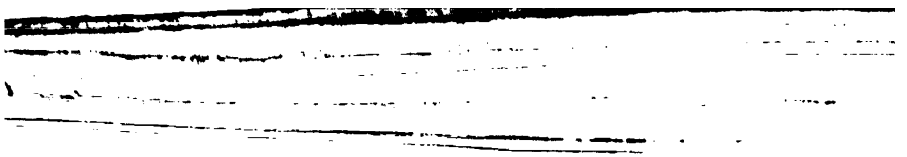
One of the most radical schemes adopted in this connection is that at the Otay Dam, near San Diego, Cal., now in course of construction, in which a web of steel plate is placed vertically through the axis of the dam across the entire gorge and from foundation to top. The dam is 130 feet high, with a width of 20 feet on top and slopes of 1 on 1 on each face. The rock cost in place about 50 cents per yard, bank measure, and the quantity required is about 140,000 yards. The steel web consists of plates 5 by 17.5 feet with a thickness of 0.33 inch for the three lower courses and 0.25 inch for those above. The plates are carefully riveted, seamed, and calked, and then painted with hot asphaltum

SWEETWATER (CAL.) MASONRY DAM.

BEAR VALLEY (CAL.) MASONRY DAM.

CRYSTAL SPRINGS (CAL.) CONCRETE DAM.

CRYSTAL SPRINGS (CAL.) CONCRETE DAM.



and faced with burlap, also saturated with asphaltum. The web is further protected by a facing of concrete on each side 1 foot thick, which spreads out to a thickness of about 6 feet at the bottom. Apparently the only question of serious doubt as to the success of this arrangement is the effect which the settlement of this great mass of rock will have upon the steel plate. If it does not seriously rupture the plate, the experiment ought to be satisfactory.

There is one disadvantage in this location of the impervious web or diaphragm in the dam. Only that portion of the rock fill which lies below it is effective in resisting the water pressure, assuming that the water can percolate freely through the rock and develop its full pressure against the steel plate. It would seem better to have imitated the Escondido structure and have lined the upper face of the dam with the steel plate, thus placing the entire mass of the rock fill behind the line of pressure.

Another effective method of making rock-fill dams tight is to face them on the upstream side with earth. In fact, this method combines the rock-fill dam with the earthen structure presently to be described.

The rock-fill dam is thus seen to be an economical structure, and, if proper precautions are taken to prevent overflow, a safe one. It adapts itself more readily to the great variety of sites met with in practice than does the masonry dam, and will doubtless be much used in future works of this character.

The third type of dams here considered, the earthen dam, has probably been used more than all other forms put together; particularly true is this of smaller works. Properly constructed and provided with necessary safeguards, it is as permanent and enduring as any other form of dam. Its great drawback is the difficulty of making a close contact with hard materials, as with rock foundations, outlet pipes, masonry, etc.

Such dams are also liable to injury from burrowing animals, and many structures have been ruined from this cause. They, of course, can not withstand the flow of water over the top and will speedily fail if such overflow takes place.

To offset these drawbacks, the earthen dam is probably the cheapest form of dam known, adapts itself best to earth foundations, can readily be made perfectly stable, and is best suited to all types of sites, particularly to those where long dams of low profile are required.

With earthen as with rock-fill dams a vital point is to secure an impervious condition to the dam. Former practice, sanctioned by long experience, was to make a puddle wall in the center of the dam. This method is much criticised in recent times because (1) it places the plane of pressure below a considerable part of the mass of the dam, which is therefore assumed to add nothing to the stability of the structure, and (2) because the structure is not homogeneous, will therefore not settle uniformly, and will have a tendency to develop seams or cracks through which the water can percolate. Although these objections are plausible and theoretically of some value, they are in no sense supported by experience, and it is doubtful if a single failure of earthen dams can be attributed to these causes. It would indeed be desirable to have the upper face of the dam the impervious surface, and thus bring the whole mass of the dam into play in increasing its stability, but practically this is not so easily done as to introduce a core of impervious material in the embankment. With due precautions no danger need be incurred from settlement. If earth be carefully deposited on the downstream side of a core of proper material (even a concrete core resting on pile

foundations) in quantity sufficient to give stability to the dam, and if earth be similarly placed above the core in sufficient quantity to insure stability to the core, regarded as a retaining wall against the earth below it when the reservoir is empty, and if reasonable precautions be observed in the workmanship, there is no reason why subsequent settling should impair the integrity of the structure.

As already stated, the spillway should not be carried over the dam unless it cannot be avoided, and then only by protecting the embankment absolutely from the flow of the water.

The upper slope of the dam should be carefully paved to withstand wave action.

An interesting method much used in recent years for the construction of earthen embankments, and, to some extent, of rock fills also, is the hydraulic method by which the material is carried to place and deposited through the agency of running water. It is evident at once that this method of deposit, where it can be practiced, must produce the most compact and homogeneous of embankments—better indeed than the most thorough tamping or rolling can secure. It requires, of course, especially favorable conditions to make it practicable. There must be a good supply of water that can be delivered well above the site of the work. There must also be an abundance of materials near to and above the site. Then, if proper sluices are constructed, the materials may be carried into place at a very small cost. The edges of the embankment are kept higher than the interior, and thus maintain a shallow pond in which the material deposits. The surplus water flows away either through pipes carried down through the embankment itself, or over the sides, where these are protected by a temporary revetment. The La Mesa Dam in California was constructed by this method. Immense embankments have been thus built on the line of the Northern Pacific and Canadian Pacific railroads, the cost per cubic yard for the work on the Northern Pacific being as low as 4.79 cents.

For the reservoir sites herein considered, masonry dams are proposed for the South Platte and Sweetwater sites, the first on the curved plan with no overflow, the second on the straight plan with heavy profile designed for an overflow dam.

Combined rock fill and earthen structures are proposed for the upper Piney site. No dams are required for the Laramie, the Lake De Smet and Loveland sites.

IV.—THE LARAMIE SITE.

This site falls under the third class considered above, viz, depression sites. It is, in fact, one of the most extraordinary examples to be found in the West. It lies southwest of the town of Laramie, Wyo., and the nearest point is distant from town about 5 miles. The site includes portions of townships 15 and 16 north, range 74 west, and townships 15 and 16 north, range 75 west. The site extends in a direction from northeast to southwest. It is about 10 miles in extreme length and 3 miles in extreme breadth. The lowest point is at altitude 7,090 feet above the level of the sea, 59 feet below the Union Pacific track at Laramie, and about 35 feet below the low-water surface of the Laramie River where the railroad crosses that stream.

The basin is inclosed by a rim of great thickness, the lowest point of which is 7,266 feet above the level of the sea. The total relief, therefore, or vertical distance between the lowest point in the rim and the lowest point in the bottom of the reservoir, is 176 feet. The following

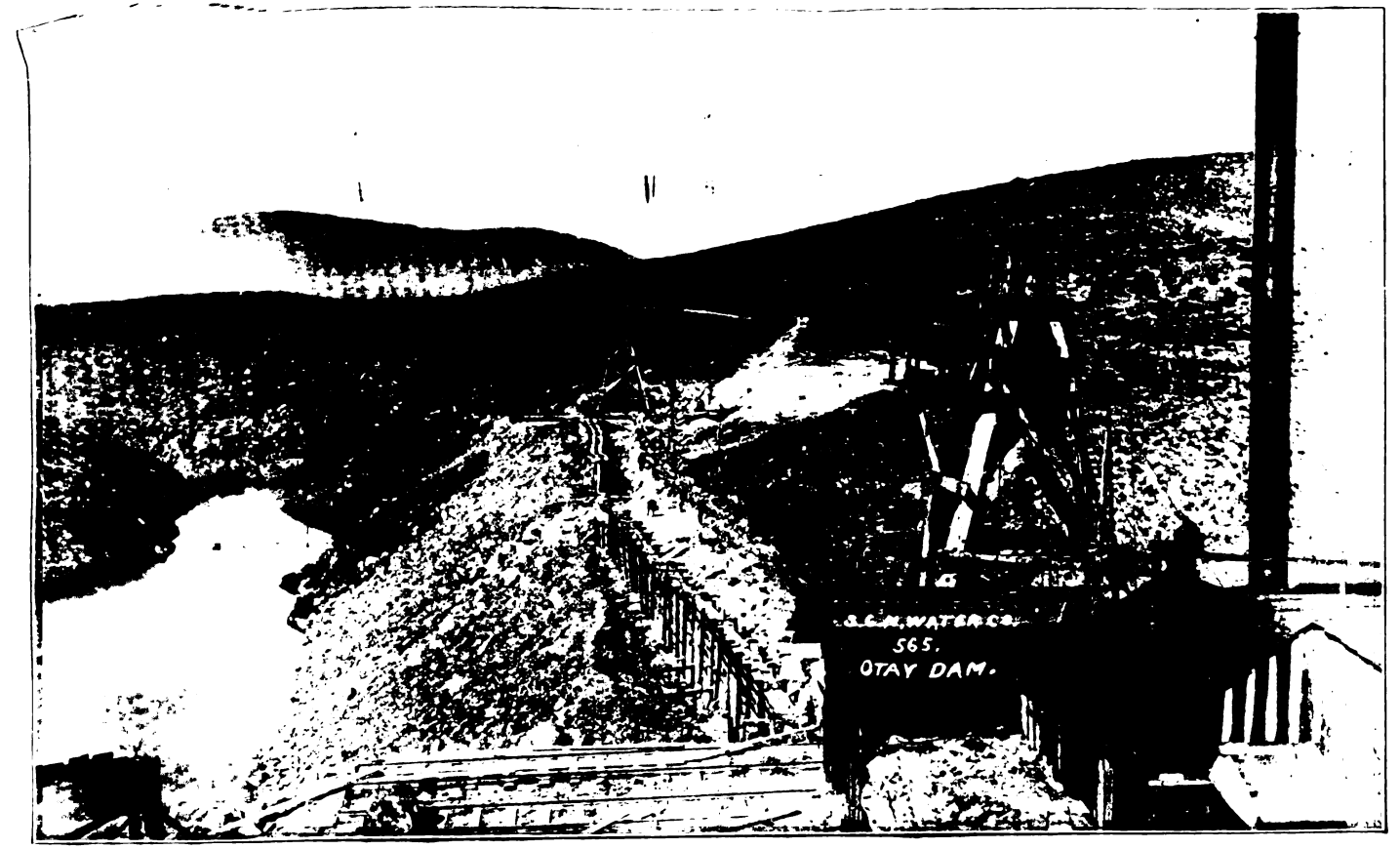
ESCONDIDO (CAL.) ROCK-FILL DAM—WOODEN LINING.

PLATE VIII.

ESCONDIDO (CAL.) ROCK-FILL DAM—WOODEN LINING.

ESCONDIDO (CAL.) ROCK-FILL DAM—WOODEN LINING.

OTAY (CAL.) ROCK-FILL DAM—STEEL CORE.



OTAY (CAL.) ROCK-FILL DAM—STEEL CORE.

OTAY (CAL.) ROCK-FILL DAM—STEEL CORE.

LA MESA (CAL.) ROCK AND EARTH FILL DAM.

LA MESA (CAL.) DAM IN COURSE OF CONSTRUCTION BY THE HYDRAULIC PROCESS.

Showing method of loosening earth to get it in suspension before taking it into carrying conduit. The conduit was built in 20-foot sections, which could be and were frequently taken apart and moved as conditions required.

table exhibits the area and capacity of this reservoir for every 20 feet from the bottom up. These statistics are also shown graphically on the map of the reservoir site.

Table of areas and capacities, Laramie reservoir site.

Contour above sea level.	Area, in acres.	Capacity, in acre-feet.
Feet.		
7,100	70	Not considered.
7,120	503	5,307.7
7,140	1,618	21,204.6
7,160	3,332	70,702.7
7,180	5,380	157,822.5
7,200	7,586	287,485.0
7,220	9,803	462,378.4
7,240	11,956	680,972.6
7,260	13,651	927,038.7

The character of soil surrounding this basin gives every appearance of impermeability. While it is largely composed of earth, there are evidences of the presence of a rock of chalky character irregularly distributed. The means were not available for an extensive series of borings, but these will be necessary only along the line of the outlet and should be made prior to the commencement of construction.

This basin lies at the eastern base of Sheep Mountain, a foothill of the Medicine Bow range, and between the Laramie River and its principal upper tributary, the Little Laramie. These two streams are the most obvious and direct resource for filling the reservoir, although others can probably be brought in. The map of the site shows the location of the two feeders which will convey the water of these streams to the reservoir. The Big Laramie feeder will be 92,000 feet long, the Little Laramie feeder 80,000 feet. The available watershed of the Laramie River is approximately 400 square miles; that of the Little Laramie 147 square miles; that of the reservoir proper about 65 square miles. The mean annual discharge of the Laramie River at the head gate, based upon four years' observations, is about 278.3 cubic feet per second; that of the Little Laramie, in proportion to area of watershed, may be taken at 100 cubic feet per second. The ordinary flood flow of the Big Laramie will not much exceed 2,000 cubic feet per second; nor that of the Little Laramie 750 cubic feet per second. The Big Laramie feeder is therefore given a maximum capacity of 2,000 cubic feet per second, and the smaller feeder a capacity of 750 cubic feet. The slope proposed (although it may be varied slightly either way if found desirable) is $1\frac{1}{2}$ feet to the mile. This gives, for a gravelly soil of the general character found in the vicinity of the site, a velocity of 4 feet per second, with a cross section of 500 square feet for the Big Laramie feeder and a velocity of 4 feet per second and a cross section of 187.5 square feet for the Little Laramie feeder. It is proposed to make this on the average half cut and half embankment, which will require an average excavation of 9.3 cubic yards per running foot for the Big Laramie feeder and 3.5 cubic yards per foot for the Little Laramie feeder. Twenty-five hundred feet of the Big Laramie ditch will lie across a depression requiring embankments about 20 feet high. Allowing for this, the total amount of excavation on the two canals is 980,000 cubic yards and 280,000 cubic yards, respectively.

In regard to the matter of filling and emptying this reservoir, its

immense magnitude interposes the gravest engineering obstacle which the entire project presents. Below is a table of the monthly discharge in acre-feet of the Laramie River at Uva, Wyo., compiled by Mr. Clarence T. Johnson, civil engineer, of Cheyenne, Wyo., from the records of the State engineer's office:

Discharge of the Laramie River at Uva, Wyo.

Year.	Apr.	May.	June.	July.	Aug.	Sept.	Remarks.
1897.....	40,728	76,208	64,278	2,527	7,245	699	Discharge during other months averages 500 acre-feet.
1896.....	6,263	14,710	15,460	1,740	3,665	560	
1895.....	6,370	6,370	17,658	14,006	964	469	

Uva is located below all the diverting ditches of the stream. The discharge, therefore, represents the water which goes to waste, and as the river is now utilized about as far as it can be in its natural condition, it also represents approximately the amount of water that must be stored in order to utilize the whole stream. It does not, however, denote the supply that can be counted on to fill the Laramie reservoir. Uva is located a great distance below the proposed head gates on the Big and Little Laramies. Although the country between is one of very small run-off, still a good deal of water must enter the stream below the head gates and above the Uva station. There is no way of ascertaining this proportion, for the conditions of watershed which prevail below the head gates are entirely different from those above, and give a much smaller run-off. With every allowance, however, I have considered that at least 20 per cent ought to be deducted from the Uva discharge to get the amount available for storage in the Laramie reservoir. The Uva discharge, based upon a mean of the three years' record given in the above table, is 87,316 acre-feet. Deducting 20 per cent leaves 69,852 acre-feet. Call it 70,000 acre-feet, or 3,000,000,000 feet in round numbers.

Now, to fill the reservoir to contour 7190, after allowing for evaporation, would take just about four years. After that the available supply of 70,000 acre-feet, less an annual loss of about 24,000 acre-feet from evaporation, would leave an available annual storage of about 46,000 acre-feet, or 2,000,000,000 cubic feet. This would represent a rise and fall in the surface of the reservoir of only about 3.5 feet, thus giving it the character of a permanent body of water.

The result of this estimate is somewhat disappointing and is much less than seems generally to be expected by advocates of this site. Mr. Maltby, who made the survey, assumes higher results. It is but fair to say that I have made an outside allowance for the loss from evaporation from the surface in placing it at 3 feet per annum plus the rainfall on the surface. It probably is not this much, for there is a watershed of at least 40 square miles tributary to the lake above contour 7260 which must run some water into the basin. The fact that there are four or five small ponds in the bottom of the basin shows that evaporation does not remove all the water that flows in. It is possible, therefore, that I should have taken a lower figure for this loss. But I have preferred to be well on the safe side, on the general principle that it is better to have expectations exceeded by reality than otherwise.

As a storage proposition, it is at once apparent that this basin is too large for the two Laramie rivers to maintain to advantage. That is, the supply available, compared with the loss from evaporation, is not

sufficient to develop the full economy of the site. If other streams can be brought in, then it may indeed be a most feasible and advantageous project. To ascertain the practicability of getting additional water for this reservoir, I had two barometric reconnaissances made across the range of mountains that separates the Laramie and North Platte rivers. There was apparently a difference of elevation between the Laramie at Woods Landing (above head gate) and the North Platte at the Colorado line of between 400 and 500 feet, the latter point being the higher. This would give ample slope for a ditch or tunnel of large dimensions to carry 1,000 cubic feet per second, and an average supply of 500 cubic feet could doubtless be derived from this source. As 500 cubic feet per second means nearly 368,000 acre-feet per annum, it is plain that a very large expenditure would be justifiable to secure it. The Laramie site would be more advantageous for North Platte storage than a site in the valley of the latter stream, because the water could be more advantageously distributed in the one case than in the other.

The necessity of filling this reservoir to about contour 7200 is owing to the great expense of constructing an outlet below it. The thickness of the rim of the basin on the line of the outlet may be seen from the following table:

At contour 7140 it is 32,300 feet thick.
At contour 7160 it is 23,700 feet thick.
At contour 7180 it is 16,800 feet thick.
At contour 7200 it is 9,700 feet thick.
At contour 7220 it is 3,750 feet thick.

It is not desirable to place the outlet above 7190, for it would take too long to get the water high enough to use. For example, if the outlet were at contour 7220, the water would not reach it for upward of ten years after filling should begin. On the other hand, to carry a capacious tunnel through the rim below contour 7160 would be enormously expensive. A compromise was therefore settled upon between these two opposite considerations. Contour 7190 has been chosen as the bottom of the outlet, for which an open cut instead of a tunnel is proposed. Where the top of the cut intersects contour 7260 the controlling works are proposed. These will consist of a masonry wall extending entirely across the cut and 10 feet below the bottom and 25 feet into the sides. Under the base of the wall a concrete wall of 10 feet square cross section will be placed to cut off all possibility of underflow. The wall as proposed will be 80 feet high, 10 feet thick at the top, and 34.5 feet thick at the bottom. For the present, however, a height of only 40 feet is proposed, leaving the completion to depend upon future enlargement. The bottom and sides of the outlet will be carefully paved for the distance of 1,000 feet to prevent any scour. Beyond that the water will be allowed to enlarge the excavation as much as it will. The cut along the paved portion will be given slopes of 1 on $1\frac{1}{2}$; the rest of the way the slopes will be 1 on 1, leaving the water to complete the excavation.

The outlet for the water will consist of 16 culverts, 3 by 2 feet, through the wall, closed by butterfly valves at the upper ends. These will give ample flow for any probable future enlargement of the reservoir.

The estimated cost of this work is given in the following table:

Right of way	$30,000.00
Big Laramie feeder, 980,000 cubic yards in all, at 7 cents per yard	68,600.00
Little Laramie feeder, 80,000 linear feet, giving 3.5 cubic yards per foot, or 280,000 cubic yards in all, at 7 cents per yard	19,600.00
Headgates on the two Laramies, at $5,000 each	10,000.00

Outlet cut, 1,084,323 cubic yards, at 15 cents	$162,648.45
3,573 cubic yards of masonry in outlet works, at $10	35,730.00
9,350 square yards of paving, at $2 per yard	18,700.00
16 controlling valves and frames, at $100 each	1,600.00
	346,878.45
Add 20 per cent for superintendence and contingencies	69,375.69
Total estimate	416,254.14

The number of acre-feet of available storage being 46,000, the first cost would be $9.05 per acre-foot.

Should borings disclose the presence of rock in the rim of a quality which would withstand a powerful flow of water without serious erosion, the proposed cut would be partially replaced by a tunnel and the controlling works would be much simplified. Estimating the cost of a capacious tunnel at $20 per running foot, and its length at 3,800 feet, it will be seen that the total cost with such a plan will not fall below that in the estimate here given.

If the cost of securing an additional 500 feet per second from the North Platte drainage be estimated at $1,000,000 (and I believe it could be secured for one-half or three-fourths of that sum), the total cost per acre-foot will fall to $3.47. It is thus seen that the Laramie reservoir is not an expensive storage proposition even when restricted to the two streams considered. When extended to a larger field, it becomes an exceptionally economical one.

The plan of cutting the reservoir site in two along the line of a ridge about midway of the length of the basin was carefully considered, with a view to reduce the size of the reservoir to proportions suitable to the two streams that are to fill it. The extra cost involved in the dividing embankment and the increased length of the Big Laramie feeder negatived a favorable view of this project.

There is now urgent need of storage of the waste waters of the Laramie River. The resources of the stream in its natural condition have been exhausted. The lands where the waters would find their principal application lie below the Laramie Mountains in the vicinity of Wheatland, Wyo. The entire flow of this stream can be advantageously used in irrigation in this section, and the project for storing that percentage of its flow which is necessary to render the whole available is one of actual immediate importance.

V.—THE SWEETWATER SITE.

This is an open-valley site, and is located on the Sweetwater River about 20 miles above its junction with the North Platte River. It lies in townships 28 and 29 north, ranges 87 and 88 west of the sixth principal meridian. As a simple proposition for the storage of water, it is almost unequaled anywhere in the West. For several miles along the site of the reservoir the river flows in an easterly direction along the southern base of a high granite ridge. At the site of the proposed dam it turns abruptly to the north and passes the ridge through a narrow chasm of very bold and striking appearance. Neither the appearance of the gorge nor any other evidence indicates that this opening was cut out by erosion. It seems rather to be a cleft in the rock formed by some convulsion of nature. Its remarkable character can best be judged from the accompanying photographs and from the section of the dam site shown on the map. Its breadth at the bottom is only about 30 feet; its depth is about 330 feet, and its width at this height about 400 feet. It stands almost without exception as the most favorable site for a great masonry dam in the world. To the east of the gorge the ridge falls

away rapidly, and at two points reaches an elevation only 100 feet above the surface of the stream in the gorge. It is this depression in the ridge that forms the limit of height to the dam.

This canyon has always been a very noted natural feature of that section of the country and has been known since 1812, when it was passed by the returning Astorians late in the fall of that year. Through the depression in the ridge just referred to lay the old overland trail to Oregon and California, and the proximity of the gorge to this great highway gave it unusual prominence in the history of travel through the West. It early received the name of the "Devils Gate," which it retains to this day.

The reservoir site above the dam is no less remarkable than the gorge itself. The river has a very gentle slope, only about 6 feet to the mile. The valley is broad and the storage capacity of the site is accordingly very great. Add to this that the site lies well toward the lower end of the valley, and it will be seen that scarcely any stream in the world is so highly favored with natural provision for the conservation of its flow as the Sweetwater River of Wyoming.

The map of this site contains all the information necessary for a complete understanding of it. A solid masonry dam of strong profile and straight plan, designed to carry the floods of the river over its crest after the reservoir is full, is proposed. The dam will be 25 feet thick at the top and 94 feet at the bottom, with a batter of 10 on 1 on the upper face and of 2 on 1 on the lower. The masonry will be uncoursed rubble, with a large proportion of concrete. The exceptional facility which the site affords for the quarrying of rock will greatly reduce the cost of this part of the work.

The height of the dam will be 100 feet above the present low-water surface at the site. This will raise the water nearly to the level of the depression in the ridge already referred to. At this height the reservoir will have an area of 10,578 acres and a capacity of 14,242,594,000 cubic feet, or 326,965 acre-feet.

It is proposed to carry the outlet works through the ridge by a tunnel running well around the base of the dam. The length of the tunnel will be about 1,000 feet and its cross section 75 square feet. This is calculated to give a flow of 1,000 cubic feet per second with a 25-foot head, and will easily drain the reservoir during the irrigation season.

The entrance to the tunnel will be considerably larger than the main trunk and will be closed by a solid masonry wall, through which the emptying culverts will extend. These will be 12 in number and will consist of cast-iron pipe of 36-inch diameter, closed by the ordinary gate valve and operated from above the top of the reservoir.

The reservoir site is occupied by two important ranches and the cost of right of way will be considerable.

Following is an estimate of the total cost of this reservoir:

Right of way	$75,000.00
Clearing of site	2,500.00
Masonry in dam, 21,534 cubic yards, at $6 per yard	129,204.00
Tunnel 1,000 feet long, at $15 per foot	15,000.00
Masonry of outlet works, 500 cubic yards, at $10 per yard	5,000.00
12 valves and pipes, at $100 each	1,200.00
Reconstruction of 10 miles of highway	2,500.00
	230,404.00
Superintendence and contingencies, 20 per cent	46,080.80
Total estimate	276,484.80

The first cost of the storage per acre-foot is therefore 85 cents.

The drainage area of the Sweetwater River above the Devils Gate is 2,492.1 square miles. There has been but one measurement of its discharge and there are therefore no reliable data upon this point. But taking the discharge of the North Platte at Orin Junction and deducing the proportion by watersheds which should go to the Sweetwater gives a mean of 319 feet per second, or 10,066,660,670 cubic feet, or about 230,000 acre-feet, per year. The reservoir is thus seen to have a capacity greater than the ordinary flow of the stream. Should the time come when all of the water is used for irrigation, the amount of storage required would probably not exceed, on the average, 5,000,000,000 cubic feet, or 115,000 acre-feet, per annum. In years of heavy flow this would be much exceeded. For reasons already given, however, a large reservoir is recommended in preference to one whose capacity is limited to actual needs. A rise and fall of 10 feet at the top of the reservoir as planned will represent the annual storage required when the stream is thoroughly utilized in irrigation. The reservoir bottom will then be uncovered over only about one-fourth of its area when at its lowest stage and it will soon acquire the character of a permanent lake. The extra cost by which this advantage is assured is but trifling in comparison with that of the whole work.

This project is not presented as one demanding immediate consideration, because the unaided flow of the North Platte River is not yet exhausted. The time is not far distant, however, when it will be all used, and when that time comes, a reservoir on the Sweetwater site will afford the most certain and the cheapest means of adding to it.

There is an important reason why early occupation of this site, even in advance of actual need of the water in irrigation, is very desirable. The cost of the right of way will certainly increase rapidly as time goes on. It is very probable that a railroad will soon be built along this valley, and, if so, it will naturally seek a route through the Devils Gate Canyon and along the immediate valley of the stream. To remove such a railroad when once built would add enormously to the cost of the work, and the best way to prevent such a contingency would be the permanent occupation and improvement of the site. At any rate, the proper authority ought to interfere to prevent the occupancy of the gorge by a railroad. This would work no serious hardship, for it is entirely practicable to carry a road over the low ridge east of the gorge and around the border of the proposed reservoir.

VI.—THE PINEY CREEK SYSTEM.

The reservoir sites examined along this stream did not come to my attention until early in August of the present year, but I found them to possess so many advantages that I determined to consider them. For this purpose I engaged the services of Mr. Fred Bond, a civil engineer, of Buffalo, Wyo., who had already done some work on these sites, to make me as complete an examination of them as the limited means at my disposal would permit. This work Mr. Bond executed with great promptness and in considerable detail. The drawings of the three sites considered, with estimates of cost, were all prepared by him. His report, appended hereto, will be found of much interest.

Piney Creek is one of the most important streams in Wyoming, and is to that State very much what the Cache à la Poudre, to be described further on, is to Colorado. It is fed from the perennial drifts that accumulate in great magnitude in the chasms and on the slopes of the Big Horn Mountains, just to the north of Cloud Peak. It is a typical

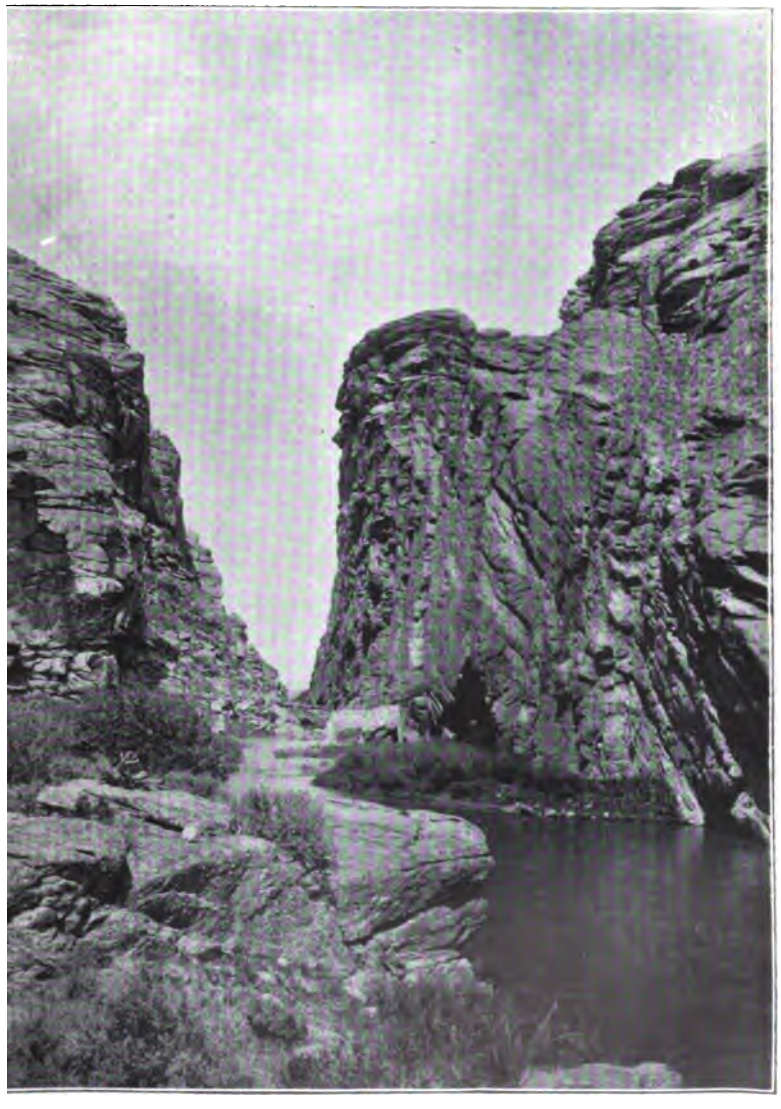
PLATE XIV.

THE "D

PLATE XIV.

THE "D

PLATE XVI.



THE "DEVILS GATE," SWEETWATER RIVER, WYOMING.

CLOUD PEAK RESERVOIR SITE, WYOMING.
From a photograph by Elwood Mead, State Engineer of Wyoming

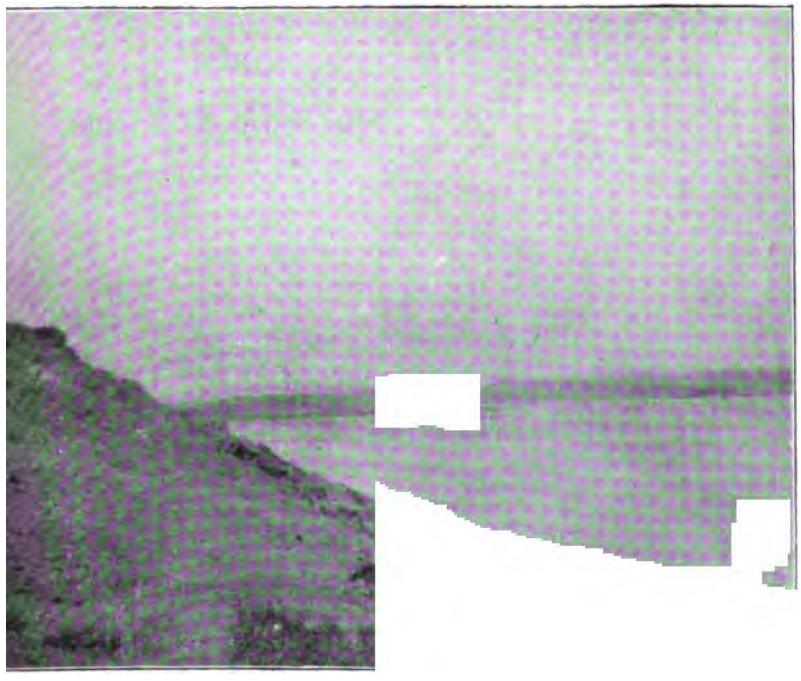
PLATE XVIII.

PINEY CREEK, JUST BELOW DAM SITE AT CLOUD PEAK LAKE.

PINEY RESERVOIR SITE, WYOMING.

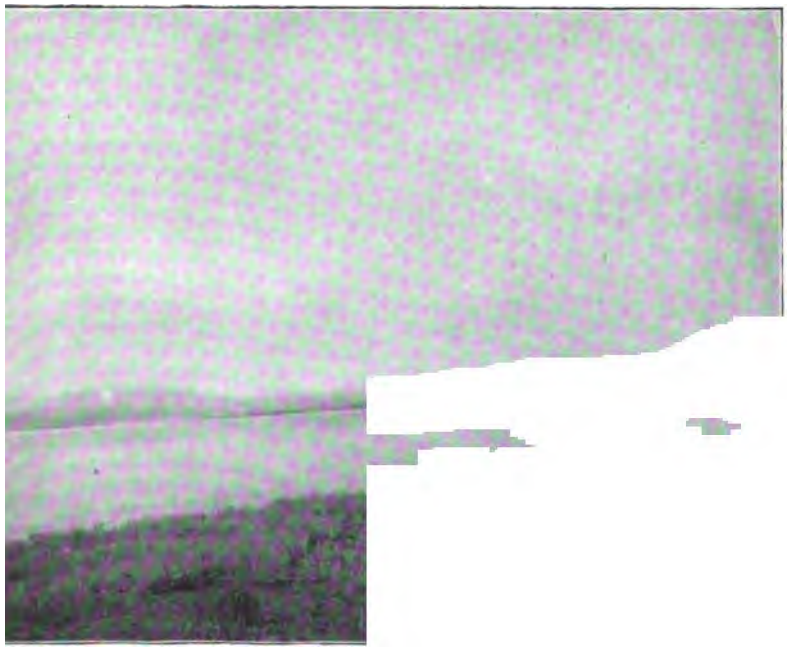
From a photograph by Elwood Mead, State Engineer of Wyoming.

PLATE XX.



LAKE DE SMET, WYOMING.

PLATE XXI.



LAKE DE SMET, WYOMING

mountain torrent, subject to no violent variations in discharge, but a good, strong stream the year round. The absence of continuous gauge observations makes it impossible to state definitely what the mean annual discharge is; but a conservative estimate, based upon such measurements as have been taken, indicates a mean flow at the foot of the mountains of about 250 cubic feet per second, with a maximum of about 1,000 cubic feet per second and a minimum of about 100 cubic feet. From the report of Mr. Bond, as well as from personal conferences by myself with farmers in the Piney Valley, it appears that an unusually large percentage of the flow of Piney Creek will have to be stored in order that all may be utilized—probably 50 per cent.

Fortunately nature has provided excellent sites for this purpose. These sites are three in number, and are, commencing with the highest, the Cloud Peak site, the Piney site, and the Lake De Smet site.

CLOUD PEAK SITE.

This is a lake site and lies at the northern base of Cloud Peak, nearly 10,000 feet above sea level, and surrounded by dense mountain forests. It is about 1½ miles long and one-half mile wide. It covers 173 acres. The photographs convey a good idea of its present appearance. It is proposed to close the outlet by a dam 34 feet high and to construct outlet works so as to draw off the water 6 feet below the present surface. The available capacity is estimated at 296,000,000 cubic feet, or 6,800 acre-feet. The drainage area above this site is about 30 square miles, and the reservoir will fill every year.

Mr. Bond has presented a plan of dam which will give a satisfactory result. To permit some minor modifications, however, which might be deemed essential for increasing the thoroughness of the work, I have increased his estimate by 25 per cent, instead of 20 per cent as in the other estimates. A table of costs is given below.

THE PINEY SITE.

This is an open-valley site, formed by a natural park 1½ miles long by 1 mile wide. It is located 6 miles below Cloud Peak Lake, at an altitude of 8,800 feet. It is proposed to close the outlet of this park by a dam 54 feet high. This will give the reservoir an area of 368 acres and a capacity of 480,000,000 cubic feet, or 11,020 acre-feet. The form of dam proposed by Mr. Bond is well suited to the site. The estimate of cost is given below. The entire watershed above the dam is 65 square miles, and the reservoir will fill every year.

Both of the above sites were recently located and filed upon by an association of farmers in the valley below, under the style of the Rock Creek and Piney Reservoir and Ditch Company. There will be no difficulty in securing a relinquishment of their rights, which they have voluntarily proposed, as will be seen from an instrument in writing executed by them, a copy of which is appended hereto (Appendix D). In fact, these sites present no complications in regard to prior rights.

THE LAKE DE SMET SITE.

This is a depression site occupied by a natural lake without an outlet. The present lake is about 3 miles in extreme length and 1 in extreme breadth, and has an area of about 1,965 acres. The water is reported to be unfit for use, but I think this must be a mistake, as it is regularly used for the watering of animals.

The site lies well out from the base of the mountains, and its possible capacity is such as to store all the surplus of the Piney not stored in the two reservoirs just described. It forms, in fact, with those two, a complete system for the stream and makes as satisfactory an arrangement as could be desired.

The surface of the lake can be raised 30 feet before the natural basin is full, and to any required height thereafter by a simple embankment at the northern end. Thirty feet depth of storage will give a reservoir area when full of 2,400 acres, and a capacity of nearly 3,000,000,000 cubic feet, or 67,600 acre-feet. The present estimate considers only this amount of storage, but it could be increased if found desirable to the full needs of the stream.

To fill the reservoir will require a feeder 3¼ miles long. The canal proposed by Mr. Bond has a slope of 4 feet to the mile, a depth of 7 feet, and will carry 727 cubic feet per second. Mr. Bond excludes four months of winter from the supply for this reservoir, but I see no conclusive reason why this should be done. It ought to be possible to overcome the difficulties arising from excessive cold weather so as not to lose this winter supply.

Outlets are provided at each end of the reservoir, that at the north end draining into the Piney and that at the south end into Box Elder Creek. Each outlet will discharge 425 cubic feet of water per second. The outlets are mainly in cut, but there is a length of 1,000 feet of tunnel at each end.

There are no private claims connected with this reservoir, but some of the land on the immediate borders of Lake De Smet and along the feeder will have to be condemned.

Following is Mr. Bond's estimate for the three sites. To each I have added 25 per cent to cover superintendence, contingencies, and such possible modifications of plan as might be developed in actual construction.

Cloud Peak Lake site.

25,015 cubic yards earth, at 50 cents	$12,508.00
10,900 cubic yards loose rock, at 70 cents	7,630.00
200 cubic yards masonry, at $10	2,000.00
300 cubic yards stone excavation, at $3	900.00
3,446 pounds iron, at 16 cents	551.00
1 3-foot sluice gate	200.00
7 miles roadway Piney to Cloud Peak Reservoir, at $150	1,050.00
Total	24,839.00
Add 25 per cent for superintendence and contingencies	6,209.75
Grand total	31,048.75

The capacity of the reservoir being 6,800 acre-feet, the first cost is $4.56 per acre-foot.

Piney site.

63,477 cubic yards of earth, at 40 cents	$25,391.00
30,120 cubic yards of loose rock, at 80 cents	24,096.00
431 cubic yards of masonry, at $8	3,448.00
7,878 pounds iron, at 15 cents	1,182.00
320 cubic yards stone excavation, at $3	960.00
2 3-foot sluice gates, at $200	400.00
7 miles road to reservoir site, at $100	700.00
	56,177.00
Add 25 per cent for superintendence and contingencies	14,049.25
Total	70,226.25

The capacity of this reservoir being 11,020 acre-feet, the cost per acre-foot is $6.37.

Lake De Smet site.

UPPER DISCHARGE CANAL.

125,209 yards earth, at 20 cents	$25,041.00	
3,550 yards earth in tunnel, at 50 cents	1,775.00	
1,000 yards concrete, at $6	6,000.00	
1 sluice gate in place, 6-foot	300.00	
		$33,116.00

LOWER DISCHARGE CANAL.

159,407 yards earth, at 20 cents	31,881.00	
3,550 yards earth in tunnel, at 50 cents	1,775.00	
1,000 yards concrete, at $6	6,000.00	
1 sluice gate in place, 6-foot	300.00	
		39,956.00

SUPPLY CANAL.

105,560 yards earth, at 12 cents	12,667.00	
66 yards rubble masonry, at $6	396.00	
18 yards concrete, at $6	108.00	
2 6-foot iron brass-mounted gates	550.00	
		13,721.00
450 acres land submerged by reservoir, at $5		2,250.00
66 acres for right of way for supply canal, at $20		1,320.00
25 acres for right of way for discharge canals, at $5		125.00
1 wooden bridge at county road crossing		200.00
		90,688.00
Add 25 per cent for superintendence and contingencies		22,672.00
Total		113,360.00

The capacity of the reservoir being 67,628 acre-feet, the cost per acre-foot is $1.67.

The cost of the whole system is as follows:

Site.	Acre-feet.	Cost.	Cost per acre.
Cloud Peak	6,800	$31,048.75	$4.56
Piney	11,020	70,226.25	6.37
Lake De Smet	67,628	113,360.00	1.67
Total	85,448	214,635.00	2.51

In no part of Wyoming has the water of streams been more fully used in irrigation than in the section of country along Clear and Piney creeks and their tributaries. The resources of these streams in their natural condition have been exhausted, yet there is abundance of land in their immediate valleys to utilize the flow which now goes to waste. The project for storing that percentage of the flow of Piney Creek which is necessary to render the whole available is therefore one of actual immediate importance. (See report of Mr. Fred Bond, Appendix B.)

VII.—THE SOUTH PLATTE SITE.

This site lies in Jefferson and Douglas counties, Colo., in township 10 south, ranges 70 and 71 west of the sixth principal meridian. It is on the South Fork of the South Platte River, one-fourth of a mile below the mouth of Goose Creek. It is about 50 miles southwest from Denver and 20 miles from the railroad at the junction of the two forks of the South Platte. Nine miles of this distance is along an abandoned railroad grade, and for the rest of the distance a good road, without heavy grades, can be built to the site of the dam.

This site is chiefly remarkable in affording an excellent place for a high masonry dam. The photographs convey some idea of its character, but this can much better be judged from the map of the site. The height of dam best suited to the locality is about 200 feet above the

datum. At this height the length of the reservoir will be about 5½ miles, the area of the water surface in the reservoir 776 acres, and the capacity 2,927,705,010 cubic feet, or 67,211 acre-feet. The area and capacity from zero to the top are shown in curves on the map of the site.

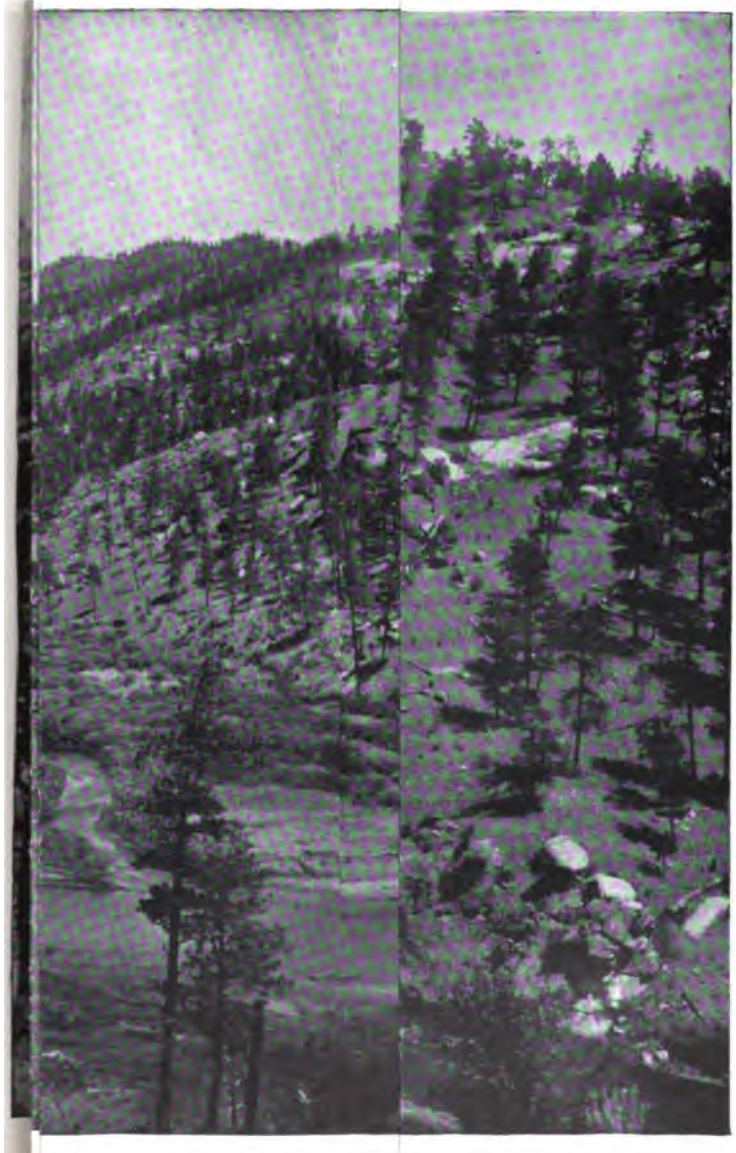
A curved plan of dam is best adapted to the topography of the site, and a curve with a radius of 300 feet is adopted in the plans. The profile of the dam is slightly lighter than that of the accepted theoretical gravity dam, but the extreme narrowness of the gorge in the lower 90 feet of its depth, and the arched form, will more than make up any deficiency in stability arising from this cause. The masonry in the construction will be uncoursed rubble, with a large use of concrete. Especial care will be taken with the work on the upper face, and particularly with that portion around the outlet pipe, to be described further on. The rock is a red granite and can be found in quantities sufficient for the entire work immediately at and above the site. Timber sufficient for all the purposes of construction can be had from trees growing on the reservoir site. In fact, all the material required, except cement, iron, and other manufactured articles, are as conveniently located as could possibly be desired.

The ridge which supports the left flank of the dam rises somewhat beyond its extremity, and then falls into a saddle, the lowest point of which is at about the same elevation as the top of the dam. This depression through the ridge affords a most perfect opportunity for the construction of a spillway. The one proposed is shown in section and profile on the drawings. It is 250 feet long, and with a depth of 3 feet will carry 4,000 cubic feet of water. The bottom of the spillway is placed 3 feet below the highest proposed contour of the reservoir, and will be provided with some form of movable dam by which the spillway can be closed if desired.

It is proposed to carry the outlet of the reservoir through the dam itself by means of a 4-foot cast-iron pipe, as shown in the drawings. The pipe will be specially cast for the work in lengths and forms to fit the location. The utmost precaution will be taken, by means of iron collars around the pipe extending into the masonry, to prevent any filtration of water along it. The pipe will be thoroughly anchored to the granite walls of the canyon, and that portion below the dam will lie in a trench excavated from the rock to receive it. The lower extremity will abut against the end of the trench to take up the longitudinal stress upon the pipe due to the pressure against the end. The last length of the pipe will be effectually closed against the passage of water. It is proposed to have the controlling valves below the dam. They will be placed in a series of twelve 15-inch lateral pipes let into the large pipe on the side next to the stream. These laterals will lie at an angle of 20° above the horizontal, and will discharge against the wall of the canyon across the stream. Considering the great pressure due to a head of 200 feet, it is believed that several small valves will be much better adapted to the work than one large one. The total pressure against a 4-foot valve would be, under a 200-foot head, about 78.4 tons.

This arrangement of the outlet places all the valves where they are entirely accessible, and it avoids the expense and inconvenience of a high water tower. There will be one larger valve at the lower end of the series, to be opened only for the purpose of flushing out solid matter which might get into the pipe, and to give access to the pipe for purposes of examination or repair. To exhaust the water from the pipe at such times, a "railroad gate," as it has been called, will be provided; that is, a heavy sliding or rolling gate that can be let down over the entrance

PLATE XXII.



SITE OF DAM, SOUTH PLATTE RESERVOIR SITE—ABOVE.

SITE OF DAM, SOUTH PLATTE RESERVOIR SITE—NARROWEST PART.

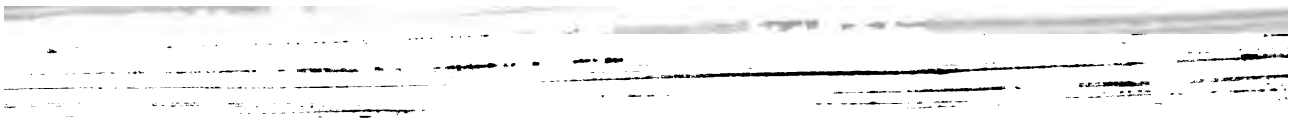
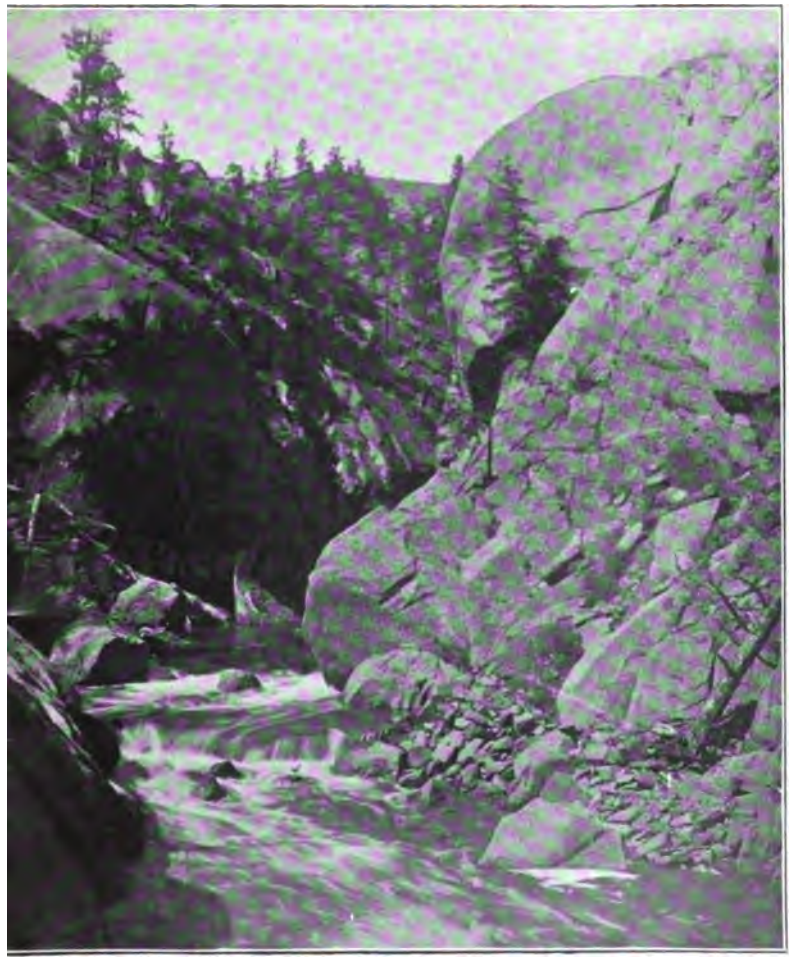


PLATE XXV.



SITE OF DAM, SOUTH PLATTE RESERVOIR SITE—BELOW.

to the outlet to close it temporarily. After necessary examinations or repairs have been made, the outlet valves are closed, the pipe fills from leakage around the upper gate, or by means of a small auxiliary opening provided for the purpose, the pressure on the gate is relieved, and it can then be raised so as to leave a free entrance for the water.

For the purpose of keeping a permanent record of the water passing the dam, a low overflow weir is proposed, at a point some distance below the spillway. This should be made with extreme accuracy and be provided with an automatic register of the gauge height.

The area of watershed above the site of the dam is 1,645.2 square miles. The mean flow of the South Platte River at Deansbury, just below the junction of the North and South Forks, as estimated from the records of a single year (1896), does not exceed 241 cubic feet per second. Of this flow about 166 feet per second, by proportion of watershed, passes the site of the proposed dam. As to the proportion that can be stored, no absolute answer can be made. But I do not think it would be safe to count on more than 60 cubic feet per second on the average, including winter flow, spring floods, and irregular storms. This would give only about 1,900,000,000 cubic feet, or 43,620 acre-feet. The loss from evaporation in excess of rainfall on the surface would not be more than 100,000,000 cubic feet annually, leaving 1,800,000,000 cubic feet, or 41,320 acre-feet, of storage on the basis of the above estimate.

The year 1896, however, seems to have been one of low water on the South Platte, and the above discharge is often very much greater. Although the above estimate shows that the reservoir would fill only about two-thirds of its capacity each year, there will be many years when it will entirely fill. It seems advisable, therefore, to develop the full capacity of the site, as here proposed.

The principal obstacle in the way of actual construction of this reservoir is the previous appropriation of the site by a private party, viz, a water company under the name of the South Platte Canal and Reservoir Company. Some placer claims have been taken up on the same site, probably more with a view of controlling the land than of developing the claims. None of these rights have been put to a beneficial use as yet, and it is questionable if they ever will be. How long they will remain in force in the absence of any attempt to develop them is not a matter of specific regulation, but rather of judicial determination. Damages arising from a relinquishment of the site to the Government can not, therefore, be definitely estimated. They ought not to exceed a reasonable allowance for actual land values and work already expended on the claims. The site is one of the most important in Colorado, and whether the present claimants would crowd their rights to an exorbitant figure in surrendering them to the Government is not a matter that can be determined except by actual negotiations for the site.

In other respects the cost of the work will be very moderate considering the somewhat remote location.

Estimate of cost.

Right of way	$50,000
Masonry in dam, 75,200 cubic yards, at $5	376,000
Outlet works, spillway, and masonry weir	20,000
Clearing of site	4,000
	450,000
Add 20 per cent for superintendence and contingencies	90,000
Total estimate	540,000

On the basis of a full reservoir, this gives a cost per acre-foot of storage of about $8.

In no part of Colorado has the water of streams been more fully used in irrigation than in the valley of the South Platte and its several tributaries. The resources of these streams in their natural condition have been exhausted, yet there is an abundance of land in the valley of the Platte to utilize the flow which now goes to waste. The project for storing that percentage of the flow of the South Fork of the South Platte which is necessary to render the whole available is, therefore, one of actual immediate importance.

VIII.—THE LOVELAND SITE.

This is a depression site, embracing two basins close to each other, each being partially occupied by a natural lake. There are many similar basins in this locality which have already been used for the storage of water. The site is about 3 miles northeast of the village of Loveland on the divide between the Big Thompson and Cache à la Poudre creeks. It lies in townships 5 and 6 north, range 68 west of the sixth principal meridian. It is about 20 miles west of the town of Greeley. It is in the midst of the finest agricultural district in Colorado, and one of the best irrigated districts of the United States. This is the locality of the well-known enterprise called the Union Colony, which was conceived and first advocated by Horace Greeley as a result of his observations and travels in the West. The development of irrigation in this vicinity has been truly wonderful and shows what can be done under fairly favorable conditions with the arid lands of the West. Irrigation is here carried on upon a scientific basis scarcely excelled even by the more costly systems of southern California. There is probably not another stream of its magnitude in the United States that has been so thoroughly studied, and the characteristics of which are so well known, as the Cache à la Poudre River, which furnishes the principal supply of water.

Here, too, the matter of water storage has received great attention, there being several large and many small reservoirs, capable of holding in all upward of a billion cubic feet of water. The system of distribution is intricate in the extreme, and to a novice seems almost too much so to be practical. It has, in fact, given rise to almost interminable disputes and litigation, and one of the heaviest items of expense in the entire system arises from this cause.

The reservoir site here considered embraces what are called the Boyd Lakes. No dam is required, for when the basin is filled to its natural capacity, the storage will equal or exceed all the supply that can be run into it.

The accompanying map shows the topography of the site, and on it is also shown the customary diagram of areas and capacities for different heights of water surface. From these it appears that the area of the reservoir when full will be 1,920.4 acres, and its capacity, above the present level of the lower lake, will be 1,992,468,378 cubic feet, or 45,740.7 acre-feet.

The outlet will be taken from the side of the higher lake, but will be on a level with the surface of the lower lake, so that the upper lake will be drained below its present level. A cut will be made, joining the two lakes so as to bring them to the same level when drained below the present ridge that divides them.

The outlet will be in the form of a deep cut 10 feet wide on the bottom, slopes 1½ on 1, and a fall of 1½ feet to the mile. This cut will be

closed near the head by a masonry dam extending 10 feet below the bottom, with a tongue of concrete extending 10 feet beneath this. Through the wall will extend six 3-foot cast-iron pipes, operated by ordinary valves at the lower ends. Below the gates the canal will be paved below the water line for a distance of 500 feet, and above the gates it will be paved to the top of the reservoir for a distance of 100 feet.

To fill this reservoir, water will be drawn from both the Cache à la Poudre and Big Thompson rivers. Although there is apparently no water in sight, over what is already appropriated, still as a matter of fact, it is estimated that enough runs to waste in flood time on these two streams to fill the reservoir nearly every year. The loss from evaporation would be very small from the fact that the natural surface of the lakes is gradually rising on account of seepage into them from irrigated lands. This shows that seepage is enough to overcome the evaporation at present going on. It would nearly, if not quite, equal the evaporation from the enlarged area.

To convey the surplus flow of the two streams to this site, two canals already in existence could be used by enlarging them, or entirely new canals could be built. The existing canal from the Big Thompson is the Loveland and Greeley Canal; that from the Cache à la Poudre is the Mercer Canal, which would have to be extended about 6 miles. These ditches are private property, with many interests dependent upon them, and their use by the Government would be subject thereto. It would be better to have new ditches constructed exclusively to feed the reservoir. But there is a grave objection to this course, in that the ditches would parallel others already constructed and would encounter considerable obstacles in working along a line already occupied. They would, of course, have to be above the present ditches in order to avoid the laterals, which occur every mile or so. The total length of new canals would not be less than 20 miles.

This reservoir site has already been appropriated, but is not likely to be developed, and a clear title could be had for the cost already expended upon it.

The total cost of this reservoir is estimated as follows:

Right of way, 2,120.4 acres, at $40	$84,816.00
Extinguishment of present rights	2,000.00
Clearing of site	2,000.00
Cut between lakes, 39,331 cubic yards, at 15 cents	5,899.65
Outlet cut, 193,662 cubic yards, at 15 cents	29,049.30
Masonry of outlet, 5,404 cubic yards, at $10	54,040.00
Paving of slopes of outlet, 3,700 square yards, at $2	7,400.00
Controlling valves and other appurtenances	2,000.00
Excavation of feeders, 303,100 cubic yards, at 7 cents	21,217.00
Two head gates and dams, at $5,000	10,000.00
	218,421.95
Add 20 per cent for superintendence and contingencies	43,684.39
Total estimate	262,106.34

This sum, divided by the capacity of the reservoir, 45,740.7 acre-feet, gives $5.73 per acre-foot.

The entire storage of this reservoir, if built, would find immediate and profitable application upon lands in its vicinity. The reservoir site lies in the heart of the agricultural section of Colorado, and nowhere else is there a greater necessity for storage of waste water of the streams.

IX.—CONCLUSIONS AND RECOMMENDATIONS AS TO THE FOREGOING SITES.

Subject to considerations presented in subsequent portions of this report, I would offer the following conclusions and recommendations in regard to the reservoir sites just described:

The accompanying tables exhibit the cost of the proposed works and a comparison with the cost of other similar works either in existence or proposed. The first table shows the cost per acre-foot for the full capacity of each reservoir regardless of the available supply. The second table shows the cost for the supply at present in sight, without future enlargement, and after evaporation has been deducted. The third table shows the cost of storage in certain American reservoirs. The fourth table gives similar data in regard to some prominent foreign reservoirs. The fifth table relates only to proposed reservoirs.

(1) *Cost of reservoir construction per acre-foot, based on full capacity of reservoir.*

Site.	Capacity in acre-feet.	Total cost.	Cost per acre-foot.	Remarks.
Laramie	414,000	$1,416,254.14	$3.42	Assumes that a supply outside the Laramie of 500 cubic feet per second can be had at a cost of $1,000,000.
Sweetwater	326,965	276,484.80	.85	
Cloud Peak	6,800	31,048.75	4.56	
Piney	11,020	70,226.25	6.37	
Lake De Smet	67,628	113,110.00	1.67	
South Platte	67,211	540,000.00	8.04	
Loveland	45,741	262,106.34	5.73	
Total	939,365	2,709,230.28	a 2.88	

a Mean for several sites.

(2) *Cost of reservoir construction per acre-foot, based upon annual supply immediately in sight, with allowance for evaporation.*

Site.	Supply acre-feet.	Total cost.	Cost per acre-foot.	Remarks.
Laramie	46,000	$416,254.14	$9.05	
Sweetwater	100,000	276,484.80	2.76	This estimate is for 40 per cent of flow of stream.
Cloud Peak	6,800	31,048.75	4.56	
Piney	11,020	70,226.25	6.37	
Lake De Smet	67,628	113,110.00	1.67	
South Platte	41,320	540,000.00	13.07	Annual available supply based upon 1896 record.
Loveland	45,741	262,106.34	5.73	
Total	318,509	1,709,230.28	a 5.37	

a Mean for several sites.

(3) *Cost of reservoir construction per acre-foot in certain American reservoirs.*

Name.	Kind of dam.	Capacity, acre-feet.	Cost.	Cost per acre-foot.
Escondido, California	Rockfill	3,500	$110,059.09	$31.44
Cuyamaca, California	Earth	114,755	959,790.00	8.37
Pecos River, Texas:				
Lower reservoir	do	7,000	86,000.00	12.29
Upper reservoir, or Lake McMillan	do	82,640	170,000.00	2.05
Tyler, Texas	Hydraulic	17,523	1,140.00	.065
Sweetwater, California	Masonry	22,566	264,074.00	11.70
Bear Valley, California	do	40,000	75,000.00	1.875
Cache à la Poudre, Colorado	Dike	5,654	125,000.00	22.00
Larimer and Weld, Colorado	do	7,461	90,000.00	12.00
Upper Mississippi reservoir system	Timber and earth.	2,146,463	678,842.25	.32
Same, on basis of estimated average annual storage	do	920,000	678,842.25	.74

(4) *Cost of reservoir construction per acre-foot in foreign reservoirs.*

Name.	Kind of dam.	Capacity, acre-feet.	Cost.	Cost per acre-foot.
Couzon, France	Masonry	1,297	$247,600.00	$190.00
Gouffre d'Enfer, France	do	1,297	318,000.00	245.00
Ternay, France	do	2,433	204,372.00	84.00
Ban, France	do	1,499	190,000.00	127.00
Pas du Riot, France	do	1,054	256,000.00	243.00
Chartrain, France	do	3,243	420,000.00	129.00
Lake Oredon, France	Earth	5,894	142,000.00	24.00
Mouche, France	do	7,011	1,003,657.00	143.00
Liez, France	do	13,051	598,418.00	46.00
Wassy, France	do	1,740	138,942.00	80.00
Patas, India	do	325	15,925.00	49.00
Ekruk, India	Earth and masonry	76,175	359,000.00	4.70
Sixteen reservoirs in Bombay		235,812	2,593,932.00	a11.00

a Average.

(5) *Cost of reservoir construction per acre-foot in certain proposed reservoirs.*

Name.	Kind of dam.	Capacity, acre-feet.	Estimated cost.	Cost per acre-foot.
Manache Meadows, California	Rock fill	248,850	$150,000.00	$0.61
Lake, California	do	46,600	225,000.00	4.83
Big Meadows, California	do	31,150	80,000.00	2.57
In Riverside County, Cal	Masonry	61,500	400,000.00	6.50
Upper Narrows Mojave River, California	do	390,000	1,742,000.00	4.50
Alpine, Cal	Natural basin and dike.	5,500	100,000.00	18.00
Rio Verde System, Arizona	Rock fill	1,618,093	4,000,000.00	2.47
Buttes, Arizona	Masonry	207,795	2,244,000.00	11.00
Queen Creek, Arizona	Rock fill	59,665	221,000.00	3.70
Little Colorado River System, Arizona	Earth and rock fill.	353,500	357,000.00	1.00
Rock Creek, Nevada	Rock fill	80,000	80,000.00	1.00
Antero, Colorado	Earth	50,640	140,000.00	2.76
Great Miami, Ohio		68,870	690,000.00	10.00
Big Cuyahoga, Ohio		66,587	600,000.00	9.00
Big Scioto, Ohio		114,784	1,500,000.00	13.00

Reservoir systems in the valleys of the Rhone, Garonne, and Loire rivers in France.

[Estimates of 1856. Never constructed.]

Name.	Capacity, acre-feet.	Estimated cost.	Cost per acre-foot.
Rhone	509,412	$13,400,000.00	$26.30
Garonne	757,575	24,000,000.00	31.68
Loire	418,962	13,000,000.00	31.03

The average annual cost of maintenance of well-built dams may be placed at 1 per cent of the original cost of construction.

The annual value of an acre-foot of water will vary from a minimum of 50 cents in Wyoming to at least $3 in southern California. It therefore appears from the above tables that each of these storage propositions stands on a safe basis, so far as return for the original cost and for future maintenance is concerned.*

In the event that Congress should favorably consider the project of developing any of these sites, I would recommend that the following be first considered:

In Wyoming, the sites on the Big Piney River.

In Colorado, the South Platte site.

My reasons for recommending the Piney system in Wyoming for first consideration are that it is least expensive, is least complicated in matter of right of way, the storage is now urgently needed for irrigation, and in all other respects it presents the fewest objections to successful development of any of the sites considered.

The Laramie site is an important one, but it would be well to make

*See further, Sec. XVIII of this Report, "Magnitude and cost of work."

some borings along the line of the outlet and investigate more fully the question of additional supply over that to be derived from the Laramie River before the work of construction should actually begin. With an important additional supply the project will be a most advantageous one; without it, a less expensive site can probably be found elsewhere in the Laramie Valley which will take care of the surplus of that stream.

The Sweetwater site is one of extraordinary advantages, and would be recommended for first consideration were it not that the storage is not immediately needed for irrigation. As a reservoir proposition, it is without equal in any other site that I know of, and its early development will save a great addition to the future cost of construction.

I recommend the South Platte site in Colorado in preference to the Loveland site, because it is less complicated with existing rights. To fill the Loveland reservoir will require two ditches, or feeders, aggregating 20 miles in length—one from the Cache à la Poudre River and one from the Big Thompson River. Existing canals could be used for most of this distance, but that would require Government partnership with private individuals in the management and control of the canal and would lead to certain misunderstanding. If new canals are built, they would meet with many similar difficulties in crossing laterals and other existing works. The water in the streams being practically all appropriated, although not all used, new complications would doubtless be encountered at the head gates. It can not be considered expedient for the Government to enter upon any work of this character where absolute and undivided control can not be secured. This reservoir site is in every way an advantageous one as a simple storage proposition. The water is all needed and has a value in this locality far above the average. I have been credibly informed that the conditions surrounding it make it difficult for private individuals or a company to develop it and secure the legitimate fruits of their investment, and that the work is in every sense one that ought to be done by the public. But it nevertheless must be considered a doubtful project for the Government to embark in. There are other similar sites farther down the valley of the South Platte which doubtless possess all the advantages of this one, without its complications, and would probably form meritorious projects. Two of these were brought to my attention, but too late for me to examine them.

The South Platte site is also to some extent complicated with existing rights, but in no sense to the extent of the Loveland site. They are rights *in futuro* entirely, practically nothing having been done to develop them. Once relinquished to the Government, there are no contiguous interests, as in the Loveland site, which must always be reckoned with. Although it is not so simple a case as the Piney site in Wyoming, still I am of opinion that no serious obstacles would be encountered in securing full rights to the site.

Should the Government take active steps in accordance with the above recommendations, I should further recommmend a first appropriation of $100,000 for the Piney system and $200,000 for the South Platte site. For the Piney system this would permit the construction of the Cloud Peak and Piney reservoirs and the acquisition of the Lake De Smet site. For the South Platte site, the amount recommended would provide for the acquisition and clearing of the site, the construction of a road thereto, the assembling of the plant, the construction of the outlet works, and the building of the main part of the dam to the height of 40 or 50 feet.

The entire construction of both the Piney and Cloud Peak reservoirs should not take more than three years.

X.—THE FUNCTION OF RESERVOIRS.

The provision of the river and harbor act directing this investigation requires, among other things, a report upon the *desirability* of reservoir construction for certain general purposes. It is important, therefore, to examine into the nature of these purposes and to inquire what the true function of a reservoir is.

In no other portion of her works has nature left so much to be done by the engineer to supplement her deficiencies as in the modification of the natural flow of her streams, for in no other respect are her works so ill adapted to the uses of man. The ideal stream would be one in which the flow should be uniform from one year's end to the other, or, if not uniform, varying directly with the magnitude of the uses to which it is put. Nature presents no perfect example of this ideal, and in only one important instance does she closely approach it. The flow of her streams is subject to the most radical variations, the maximum discharge of the larger ones often being as much as thirty times the minimum, while in the smaller streams the ratio is much greater. These irregularities of flow have no economical relation to commercial or other uses of the stream. In the autumn season, when crops are being moved and the demand for transportation facilities is at a maximum, the streams are in their lowest stage and their navigation subject to the most serious interruption of the entire year. In regions dependent upon the flow of the streams for agricultural development high water occurs at such times and in such magnitude that it can not nearly all be used. The result is that millions of acres of fertile land remain in a desert condition where they might be made productive if only the waste water could be utilized. In fact, all enterprises dependent upon the use of running water are liable to interruptions and suspension for indefinite and irregular periods, and the benefits which come from uniform and continuous use are not to be expected from them.

The most formidable evils arising from this variable condition of natural streams are experienced in the deficiency period, but the period of excess has likewise great disadvantages. It not only comes at a time when ordinarily there is least need of it, but it not infrequently brings with it appalling disasters. Among the most calamitous of natural visitations, considering their frequency and general distribution, are great floods. They hold the record even above earthquakes and storms. They mark the history of nearly every stream, great or small, and the loss of life and property from this cause, in the history of the past, transcends calculation.

It is not surprising, therefore, that one of the chief concerns of the engineer is the amelioration or prevention of the evils of this unfortunate arrangement of nature. Millions of dollars are annually expended to make up for the deficiency of water in seasons of drought, and like sums to prevent or alleviate the evils of excessive flow. Singularly enough, the measures generally adopted are put forward in disregard of one of the commonest rules of scientific practice. If an evil condition of things is to be corrected, the rational method of procedure is to remove the cause. In all river engineering, however, the measures adopted look only to the palliation of results, and leave the cause untouched. River channels are dredged out in low water, and levees are built to protect from floods in high water. Scarcely anywhere is the effort made to prevent the occurrence of either high or low water. It would naturally follow that, if great evils result from the variable flow of streams, the primary and fundamental object of the engineer who is called upon to correct them would be to make this flow uniform.

Whether or not this object is possible of realization (and if it is, by what means) is therefore one of the first questions which should be settled in any comprehensive project for the regulation of the flow of streams.

Inasmuch as human agency can exercise no appreciable influence over those climatic conditions upon which variations of stream flow depend, such as the precipitation of moisture and the melting of snow, it is evident that the ultimate causes of the evil conditions just described must ever elude the efforts of man to control them. The *sources* of the streams are clearly destined to remain as variable in the future as in the past. The only possible method by which uniformity of flow can be secured must therefore be by storing the surplus waters in seasons of flood and releasing them in seasons of drought. The agencies employed for this purpose are called reservoirs (Latin *re-servare*, to keep back).

There is an additional motive for the use of reservoirs besides that of securing uniformity of flow. Over a large portion of the land area of the earth in civilized countries the climate of winter prevents any considerable use of the streams. Even if the flow were entirely uniform, that portion which takes place in the season of cold weather would mostly be lost. To derive any benefit from it, it must be stored and held over for the season of warm weather.

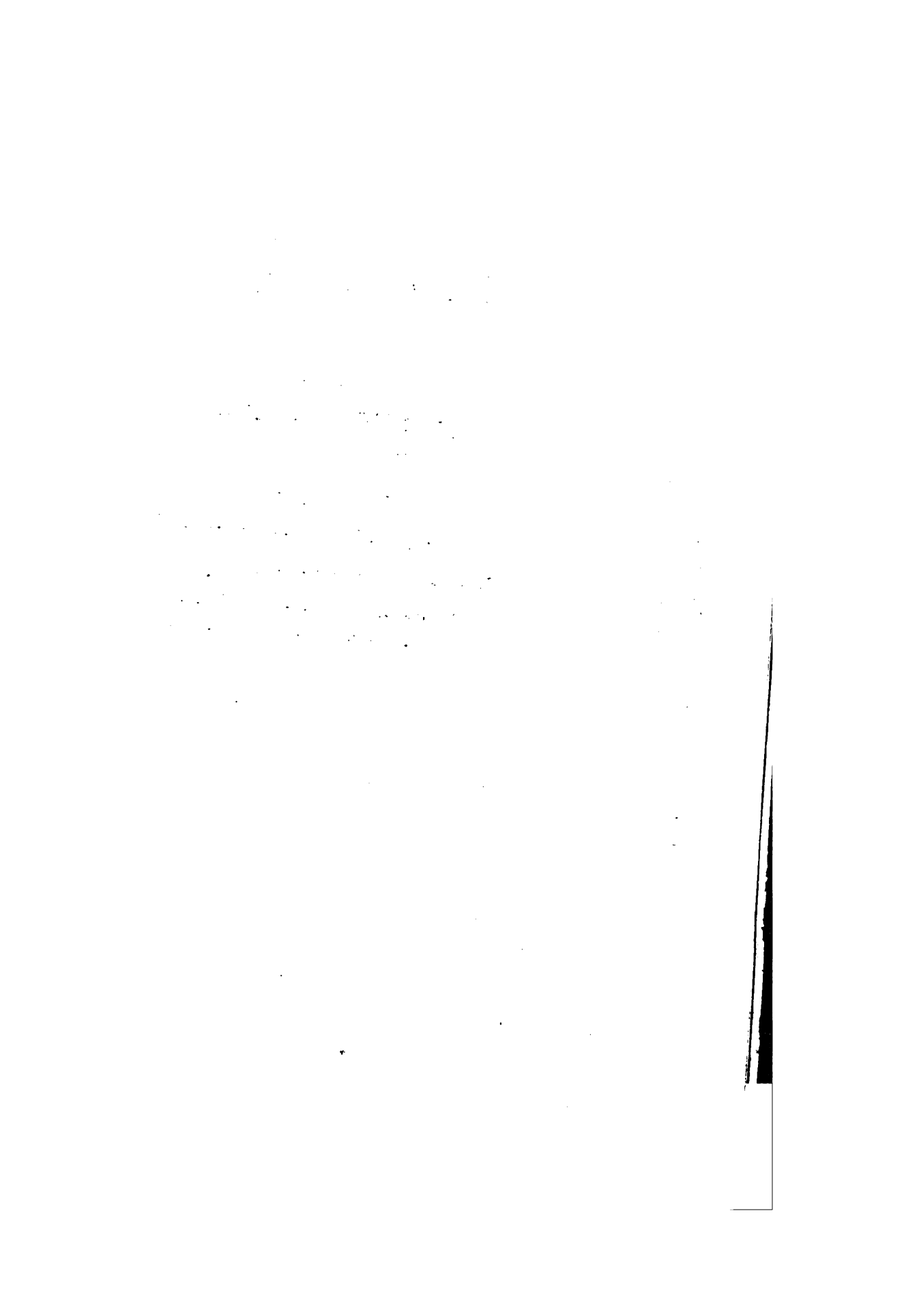
These two purposes, viz, the attainment of uniformity of stream flow and the transfer of the winter supply to the summer months cover the entire argument for reservoir construction. Even reservoirs built for city supply, milling purposes and the like, which seem but little related to regularity of stream flow are in reality caused directly by it, for if streams were uniform in flow the supply might as well be taken directly from them without the intervention of reservoirs.

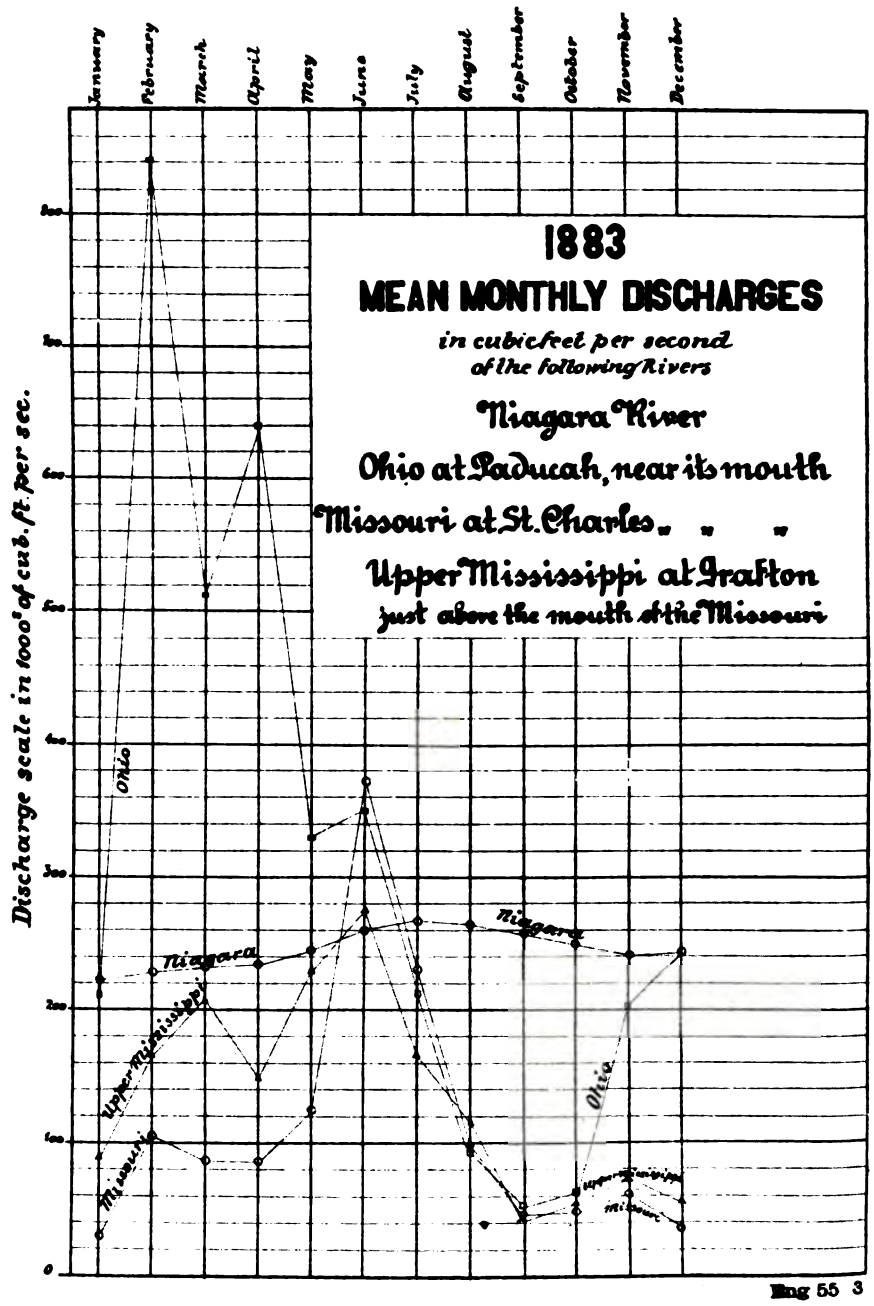
At first thought it would seem that in storage reservoirs lies the whole solution of the river problem. To store the surplus in flood season and use it in the season of drought ought apparently to strike at the root of the whole difficulty, and to render unnecessary those palliative measures which alone have hitherto received the sanction of the hydraulic engineer. Why so obvious a remedy has never yet been extensively applied will appear in the course of this report.

XI.—NATURAL RESERVOIRS.

Nature presents abundant examples of the effective control of stream flow through the agency of reservoirs. There are indeed comparatively few streams whose flow is wholly uninfluenced by such action. The most perfect example in the world, both as to the magnitude of the stream and the completeness of control, is the St. Lawrence River, embracing the great chain of North American lakes. Considering only that portion of the system which lies above the Falls of Niagara, let the flow at the outlet be compared with that of other streams of similar magnitude. For this purpose take the Niagara River at Buffalo, the Ohio at Paducah, Ky., the Missouri at its mouth, and the Mississippi just above the mouth of the Missouri. The following table gives the area of watershed in square miles and the mean annual discharge in cubic feet per second of each:

	Niagara.	Ohio.	Missouri.	Mississippi.
Watershed	265,095	205,750	530,810	171,570
Discharge	232,800	307,000	100,000	130,000




January
February
March
April
May
June
July
August
September
October
November
December
1883
MEAN MONTHLY DISCHARGES
in cubic feet per second
of the following Rivers
Niagara River
Ohio at Paducah, near its mouth
Missouri at St. Charles " " "
Upper Mississippi at Grafton
just above the mouth of the Missouri
Discharge scale in 1000's of cub. ft. per sec.
Ohio
Niagara
Upper Mississippi
Missouri
Eng 55 3

The above discharge for the Niagara River is based upon 25 years' record (1871–1895); that for the Ohio and Upper Mississippi upon six years' record (1880–1885), and that for the Missouri upon twelve years' record (1879–1890).

The accompanying diagram exhibits graphically the variations of flow in these streams for the period of a single year (1883). The curves represent only monthly means. The maximum and minimum discharges, except for Niagara, show a much greater divergence, the ratios $\left\{\frac{\text{maximum discharge}}{\text{minimum discharge}}\right\}$ for the above year being as follows:

Niagara,* 1.19; Ohio, 28.22; Missouri, 29; and Upper Mississippi, 10.29.

This striking dissimilarity in the regimen of streams of similar magnitude and, with one exception, of similar climatic conditions is entirely due, of course, to the reservoir action of the Great Lakes. Of that portion of the St. Lawrence drainage basin which lies above Niagara Falls, viz, 265,095 square miles, 87,400 square miles, or almost one-third, is made up of the water surfaces of lakes Superior, Michigan, Huron, and Erie. One foot upon this immense area represents 2,436,000,000,000 cubic feet—greater than the excess of the late Mississippi River flood at Cairo above the bankful stage.

The mean annual fluctuation of Lake Superior, based upon twenty-five years' observations (1871–1895), is 0.93 foot; of Lakes Michigan and Huron, 1 foot; of Lake Erie, 1.16 feet. This fluctuation represents an annual storage of 2,419,000,000,000 cubic feet of water, equivalent to about 153,000 cubic feet per second for a period of six months. The maximum annual fluctuation during the above period is just about twice the above mean and of course represents twice as much water stored.

In addition to the annual fluctuation, there is constantly going on a periodic change which often requires several years to complete the cycle. As an illustration of this characteristic of the Great Lakes, take the period of eight years from 1872 to 1879, inclusive, during which the mean annual level of the four upper lakes rose for a period of four years and fell during the following three years. The rise in mean level was, for Lake Superior, 1.03 feet; for lakes Michigan and Huron, 2.02 feet, and for Lake Erie, 1.97 feet. The total storage represented by this rise of mean level was 4,000,000,000,000 cubic feet. The fall in mean level following the rise was, for Lake Superior, 1.63 feet; for lakes Michigan and Huron, 1.46 feet, and for Lake Erie, 1.17 feet—equivalent to 3,627,000,000,000 cubic feet. After this fall the mean level began to rise again.

The foregoing figures convey some faint idea of the magnitude of the storage of the Great Lakes, and of the way in which it operates to preserve a balance not only between the wet and dry seasons of each year, but between those cycles of wet and dry years which are continually recurring. These reservoirs absorb the flood waters of spring and pay them out in the following dry season, thus preventing floods on the one hand and low water on the other. And while these seasonal changes are going on the lakes respond to the varying conditions of

*There are irregular fluctuations of short duration, but of considerable magnitude in the discharge of the Niagara River, due to wind storms on Lake Erie. They are not taken into consideration here for the reason that they arise from causes which do not operate on the other rivers and which have no connection with the purpose of the above comparison.

longer periods, levying upon years of more than average precipitation in order to maintain a flow in the outlets during the years of deficiency which are certain to follow.

The result of this storage action of the Great Lakes is to produce a river system radically different in its general characteristics from nearly all other streams. Such conditions as high and low water, as elsewhere understood, are here entirely unknown. Commerce pursues its way through these lakes and rivers without serious hindrance except when ice closes the way; and the river and harbor engineer has little to do with low water problems or protection against floods, but rather with the deepening of harbors and connecting channels for an ever-increasing size of vessels and volume of commerce.

The vital function which the fluctuation of levels, both annual and cyclic, plays in the economy of the Great Lakes is doubtless not generally appreciated even by the engineering profession. Only recently distinguished engineers have boldly asserted that this fluctuation of levels is an evil which must not be suffered to continue, and they have proposed plans by which it may be corrected. Yet nothing is more certain than that any curtailment whatever of these fluctuations, either annual or cyclic, can be accomplished only by a corresponding curtailment at certain seasons of the discharge of the lake outlets. How far this can be done without injury to public interests is the real point at issue in the lake level question.

Besides the Great Lakes of the St. Lawrence Basin, there are many other natural reservoirs in various parts of the world. In order to convey some idea of their geographical distribution, magnitude, and regulating influence upon stream flow, the following list of the more prominent examples is presented:

List of prominent examples of natural reservoirs.

Name of lake.	River system.	Elevation above sea level.	Area.	Percentage of area to entire watershed.	Storage in billion cubic feet represented by a fluctuation of 1 foot.	Remarks.
		Feet.	*Sq. miles.*			
Superior	St. Lawrence	601.6	31,800	39.5	886.5	Authority: Report of United States Deep Waterways Commission, 1896.
Michigan	St. Lawrence	581.2	22,400	32.9	638.4	
Huron	St. Lawrence	581.2	23,200	30.8	646.8	
St. Clair	St. Lawrence	575.3	495	7.3	13.8	
Erie	St. Lawrence	572.8	10,000	34.5	278.8	
Ontario	St. Lawrence	246.3	7,450	22.6	207.7	
Baikal	Yenisei	1,360.0	12,430	6.0	346.5	Encyclopædia Britannica. Watershed scaled from map.
Victoria Nyanza	Nile	4,000.0	27,000	24.0	752.7	Encyclopædia Britannica. Watershed scaled from map. Accuracy only approximate as data are of doubtful authenticity.
Albert Nyanza	Nile	2,300.0	2,000	12.5	55.8	
Tanganyika	Congo	2,700.0	12,650	12.0	352.7	
Nyassa	Zambesi	1,600.0	9,000	24.0	250.9	
Titicaca	Desaguadero	12,600.0	3,200	17.0	89.2	Encyclopædia Britannica. Watershed scaled from map.
Geneva	Rhone	1,218.0	223	8.0	6.2	
Constance	Rhine	1,306.0	208	4.0	5.8	
Neuchatel	Rhine	1,427.0	92	11.9	2.6	
Como	Po	670.0	64	4.0	1.8	
Maggiore	Po	646.0	83	3.3	2.3	
Garda	Po	320.0	135	19.4	3.8	
Yellowstone	Missouri	7,741.0	139	15.9	3.9	United States Government reports.

The moderating influence of any of these lakes upon the streams below them is, of course, very great. Lake Geneva, for example, in the great flood of 1856 discharged only 11,400 cubic feet per second at the maximum, as against 56,480 cubic feet which it was receiving from its watershed.

In Italy the lakes on several of the northern tributaries of the Po have long been noted for the control which they exercise over the streams flowing through them. The violent and destructive floods which are characteristic of other tributaries of the Po are largely absent from those streams which flow through the lakes.

The flow of the Rhine in its upper source is said to be subject to much less variation than other streams similarly conditioned except as to natural reservoirs.

In 1892 there occurred one of the most disastrous floods that ever took place in the region about the sources of the Missouri and Yellowstone rivers. The destruction along some of the streams was very great. Roads and railroads were washed away, bridges destroyed, and much other damage done. But the Yellowstone River below the lake rose only a few feet, and that so gradually as to give timely notice of any possible damage.

There are many thousands of other lakes scattered over the globe that act as regulators of the streams which drain them, their efficiency in this respect being proportional to the percentage which their areas bear to the tributary watersheds. Certain it is that the aggregate influence of these reservoirs is very great, and the striking difference often noted in the characteristics of the flow of streams with similar watersheds may largely be traced to this cause. Take, for example, the figures already quoted giving the ratios between high and low water on the Ohio, Missouri, and Upper Mississippi rivers for 1883, and also the corresponding ratios for the mean of the six years 1880–1885. These ratios are: For 1883, Ohio 28.2, Missouri 29, Mississippi 10.3; for 1881–1885, Ohio 21.7, Missouri 18.4, Mississippi 9.3.

The Upper Mississippi watershed lies between those of the Ohio and the Missouri, and the climatic conditions which prevail there ought to partake somewhat of those which prevail on each side. At any rate, it is impossible to suppose any such pronounced difference as would account for the above difference in ratio. The high-water discharge in the Ohio and Missouri often amounts to nearly thirty times the low-water discharge, while the mean ratio for a series of years is about twenty. For the Upper Mississippi the figures are only 10.3 and 9.3. No explanation of this fact seems so reasonable as that which attributes it to the moderating influence of the great number of natural lakes upon the head waters of this stream.

XII.—ARTIFICIAL RESERVOIRS.

While it is impracticable, for reasons stated farther on, to imitate nature on the scale of her own work in the construction of reservoirs, her example has nevertheless been followed very extensively on a smaller scale. In fact, works of this character have been built for a variety of purposes since the remotest antiquity. The storage of water for feeding canals is a prominent example. The greatest reservoir systems yet constructed have been designed to maintain the navigable condition of natural waterways. Many reservoirs have had as a prominent reason for their construction the prevention of floods in the valleys below them, although this has seldom if ever been an exclusive

reason. Storage of water for city supply, the development of power, and other industrial uses is one of the most familiar of modern enterprises. Finally the field of irrigation, which already presents many examples of great reservoirs, bids fair to outstrip all other fields in the production of works of this character. In all these examples of reservoir construction the purpose has been to correct the inequalities of nature—to prevent the rapid and destructive flow of rivers at seasons when not needed and to augment and reenforce that flow when the need does exist.

One of the most extensive artificial systems ever built is to be found in Russia at the head waters of the Volga and Msta rivers. The Volga River, the greatest in Europe, 2,325 miles long, and navigable nearly its whole length, rises in the Province of Tver, within 200 miles of St. Petersburg, and empties into the Caspian Sea in the opposite extremity of European Russia. The Msta River has its sources interlaced with those of the Volga, but flows in the opposite direction, and its waters find their way, through the Volkhoff River, to Lake Ladoga, and ultimately to the Baltic Sea.

The sources of the Volga and Msta are in a flat, marshy, wooded country, about 665 feet above sea level, covered with innumerable lakes, presenting conditions not unlike those which prevail at the sources of the Mississippi River in our own country. For a long period in the past these two river systems were connected by artificial waterways, and the seaport of the upper Volga was upon the Baltic. The extreme low water which is characteristic of the Volga and other Russian streams prevents navigation in their natural condition except in seasons of high water. To ameliorate this condition, advantage was early taken of the exceptional reservoir facilities offered by the lakes referred to, and dams of a cheap character were constructed across their outlets. The reservoir system has now been developed to great perfection and effects an important improvement both in the Volga and the Msta, rendering them navigable for nearly three months longer than they would be without this aid.

These reservoirs store about 35,000,000,000 cubic feet of water in all, of which 20,000,000,000 can be used in the Volga and 20,000,000,000 can be turned in the other direction, there being apparently a storage of about five or six billions that can be used in either direction. The largest and most important of these reservoirs, and one of the largest in the world in point of capacity, although insignificant in depth and containing dam, is the Verkhnevoljsky Reservoir. So slight is the fall of the stream in this region that, although the dam produces a maximum elevation of water surface at its site of only about 17.5 feet, the water backs up a distance of about 60 miles and includes several lakes. The low-water season capacity of this reservoir is about 14,000,000,000 cubic feet, and the average season storage is much greater. Its effect upon the low-water flow of the river below the dam is to raise its normal surface 2.8 feet at Rjef, 96 miles below; 1.4 feet at Tver, the mouth of the Tvertsa, 212 miles below, and 0.14 feet at 410 miles below. At the mouth of the Tvertsa the storage of the Zavodsky Reservoir comes in and helps out the navigation below. The total navigable distance on the Volga over which the beneficial influence of these reservoirs is felt is upward of 450 miles.

On the Msta slope there are no fewer than 10 important reservoirs, all of them being on the sites of natural lakes, the total storage aggregating about 14,000,000,000 cubic feet. As already stated, about 6,000,000,000 cubic feet of storage which really lies on the Volga slope, including the

Zavodsky reservoir, formerly was and still can be turned into the Baltic drainage. This entire system of summit reservoirs that can be used to feed the Msta is called the Vychnevolotsky system. It affords material improvement to the navigable condition of Msta and Volkhoff rivers during the period of low water.

The system of reservoirs just described is certainly a great success, and upon it much of the prosperity of the surrounding country depends. It is probably the most complete example in the world of the joint results of flood prevention and the improvement of navigation produced by artificial reservoirs. It has an importance, however, which it could not have in this country, even with equal physical advantages, for railroads here do a far greater proportion of the transportation business than in Russia. But the example shows how far favorable natural conditions can be made to improve the low-water conditions of streams.

The largest artificial reservoir system ever yet constructed is that at the head waters of the Mississippi River. The natural conditions prevailing in that region are very similar to those in Russia just described. The country about the sources of the Mississippi, where the reservoirs are constructed, is about 1,200 feet above sea level. It is dotted with an immense number of lakes, the total number having been estimated as high as a thousand. Some of the larger of these lakes afford exceptionally favorable opportunities for the inexpensive storage of water. The dams required are low structures, but the area over which the water is raised by them is so extensive, that the cost per unit of volume stored is probably the smallest ever yet realized.

These remarkably favorable natural conditions for the storage of water have long attracted public attention and were made the subject of an able official report by Gen. G. K. Warren as early as 1870. Exhaustive surveys followed at a later date, and in 1881 actual construction was begun. Up to the present date there have been constructed five reservoirs, with an aggregate capacity of 93,400,000,000 cubic feet, at a total cost of $678,302.25.[1]

The average annual storage of these reservoirs is estimated at about 40,000,000,000 cubic feet, equivalent to about 5,200 cubic feet per second for a period of ninety days. This supply is estimated to increase the gauge height at low water at St. Paul, 357 miles below, from 1 to 2 feet.

The original investigations, embracing the States of Minnesota and Wisconsin, indicated a practicable storage in Minnesota of 95,000,000,000 cubic feet, and in Wisconsin of 79,000,000,000 cubic feet, or a total in the two States of 174,000,000,000 cubic feet. There is probably little doubt that the system could be extended so as to secure a storage of 150,000,000,000 cubic feet in the two States, an equivalent of about 20,000 cubic feet per second for ninety days. From the results already obtained, it is probable that this storage would not cost above $2 per acre-foot. The effect upon the navigable stage of the river would, of course, vary with the locality considered, and would diminish rapidly with the distance downstream. But considering that such an improvement is of the most permanent character, depending only upon the maintenance of the dams for its perpetuity, the above cost can not be considered excessive when compared with the vast outlay for the mere temporary improvement of these rivers by present methods. A permanent increment of from ten to twenty thousand cubic feet per second to the low-water stage of even so large a stream as the Mississippi River is not to be passed over as a matter of small importance.

The Volga and the Mississippi rivers constitute the only two *systems* of artificial reservoirs yet constructed, and the only ones designed to improve the navigable condition of streams in their natural condition.

The construction of reservoirs to feed artificial waterways has been resorted to extensively, particularly in France, and to a considerable extent in this country. Inasmuch as the expenditure of water in canals is a matter of very exact determination, the storage required for this purpose can generally be estimated with great definiteness.

The construction of reservoirs for municipal purposes is too common a matter to require particular mention. It is sufficient to say that nearly every city in the world of above 100,000 population has storage facilities of greater or less extent to help out its water supply.

The principal development of storage reservoirs for irrigation purposes has taken place in Spain, in France and Algiers, in India, and in the United States. As already stated, the future extension of this class of storage works, particularly in our own country, promises to outstrip all others.

For such industrial purposes as the operation of factories and the like many reservoirs have been constructed both in France and in this country. They are generally of small capacity, very costly per unit of water stored, but profitable on account of the great use made of the water. Some of these reservoirs serve an important purpose in protecting the valleys below from floods.

XIII.—RESERVOIRS AND FLOOD PREVENTION.

Every reservoir built along the course of a stream is, to some degree, a protection against floods in the valley below. The extent of this protection depends, of course, almost entirely on the ratio of its capacity to the flood discharge. A reservoir that can store the entire flow of a stream—as, for example, the proposed reservoir on the Sweetwater—is an absolute protection against floods for a considerable distance below. It is difficult to propose any general rule for the extent of this control, but, assuming a general similarity of watershed, it would seem not unreasonable to say that it ought to be decisive to at least such a distance below as will give an additional watershed to a stream equal to twice that above the reservoir. This is simply saying that, in the general case, the reduction of a flood wave by one-third of its volume will rob it of its destructive character.

But in a great many cases this control extends very much farther. For example, in the case of a flood caused by the rapid melting of snows in the mountains, reservoirs below which can impound this flood will protect the entire valley so far as its destructive influence would otherwise have reached. When it is remembered that the volume of a destructive flood is only a part—probably always less than half—of the total flow of a year, it will be admitted that a storage capacity equal to one-fourth of the run-off, well distributed throughout a watershed, will practically eliminate the evil effects of floods in its streams. This is the percentage shown farther on to be sufficient for the purposes of irrigation. (See page 60.)

It is not necessary, though important, that a reservoir should be empty when a flood comes. Even if full, it still moderates the flow of the stream below, the effect varying directly with the superficial area of the reservoir when full, and inversely with the capacity of the spillway. In this respect it acts precisely as does a natural lake. For

example, if the spillway of a reservoir or the outlet of a natural lake be of such dimensions as to require a considerable increase in the depth of water to give much of an increase of discharge, every increment of this depth of outlet means also an increment of the same depth over the entire reservoir. A flood passing such a reservoir will be reduced by the storage resulting from this increment, and before it can produce a full discharge it must fill the reservoir to the necessary height above the bottom of the spillway. A large reservoir is, therefore, even when full, always a perfect protection against sudden floods. In the case of long-continued floods it greatly retards the arrival of maximum effect and gives ample notice of its approach.

In fact, this is a very important feature of reservoir action, even where the capacity of the reservoir is not sufficient entirely to prevent the flood. It does prevent freshets—that is, sudden floods—and in smaller streams it is often the suddenness quite as much as the magnitude of floods that causes damage and loss of life.

A reservoir ceases to be any protection if a flood continues long enough to fill it to such a height that the discharge at the outlet is equal to the entire inflow. The same is true of the restraining influence of forests. A sudden and heavy precipitation of short duration, which might produce a severe freshet in a deforested region, would probably experience considerable retardation, and even reduction, if it should fall upon a forest-covered region; but if the rains continue long enough to exhaust the retentive capacity of the forest soil, to fill all the springs and replenish the ground storage, then forests cease to be any protection whatever. In fact, the presence or absence of forests in a vast watershed like that of the Mississippi River is without appreciable influence upon the great floods.

In the case of floods, which are the results of combinations of discharges from the various tributaries, reservoirs may actually operate to increase the combination. Take for example the natural reservoirs at the sources of the Mississippi. While they restrain the flood excess in that stream, they keep up a heavy flow for some time after the flood has passed. If this larger flow happens to come in with a flood crest at the junction of some tributary below, it will actually increase the combination over what would have been the case without the reservoirs. In the French investigations, presently to be described, the dams proposed for restraining floods were to have open sluiceways without means of closing them. In the ordinary flow of the stream all the water could pass through. But they were to be so proportioned that when the flow should pass a certain point the surplus would be retained in the reservoir, the outflow being always limited by the capacity of the open sluices. The arrangement was, therefore, precisely like that of a natural lake without a dam across the outlet. The outflow could never be entirely restrained, and it would increase in proportion to the height of water in the reservoir. Now, in the case of a large stream like the Rhone, where flood *combination* is the really dangerous thing, it was found that these reservoirs, had they actually been constructed, would have increased certain floods. They would have maintained a heavy retarded flow on some tributaries which in their natural condition would have entirely run out before the arrival of floods from other tributaries. As it happened, this retarded flow in the one case would have come upon a flood crest in the other, and would actually have increased the natural combination. This, of course, could not be true of reservoirs with closed sluices,

unless, as above stated, the reservoirs were entirely filled with the flood passing over them.

It has been argued that in the same way the St. Francis Basin, if open, may aggravate floods on the Mississippi whenever a high crest follows a preceding crest by an interval of time long enough to permit the overflow from the first crest to reach the foot of the basin simultaneously with the arrival of the second.

It is at any rate clear that the efficiency of reservoirs in moderating great floods would have to be a matter of judicious management in controlling combinations quite as much as of actual capacity.

Another matter to be noted in this connection is that flood protection and industrial use are not entirely compatible objects. To serve the former purpose alone the reservoir should be kept empty until the flood arrives, so that its whole storage may be available. But this might leave the reservoir only partly filled when its supply is needed for other purposes. Generally, therefore, the whole capacity of reservoirs built for these joint purposes can not be counted on for flood protection. It would probably be unsafe to allow a higher efficiency in this respect than 50 per cent.

For reasons to be fully considered further on, very few, if any, reservoirs have been built for the exclusive purpose of protecting against floods the valleys below them; but there are numerous examples where this has been an important consideration in their construction. Two cases may be cited in France. The celebrated dam at the Gouffre d'Enfer, on the river Furens, near St. Etienne, was built largely to protect St. Etienne from the destructive freshets of the Furens. It was of course expected to make use of the stored water for industrial purposes, which in a thickly populated district could not but be important. As to the results obtained, the expectations in regard to flood protection have been fully realized.

The Ternay Dam likewise had as an important motive for its construction, the protection of the town of Annonay from the floods of the Ternay, although in this case, as in that just cited, industrial uses of the stored water were considerations of great weight. The result of this work, as to flood protection, has been a success.

There are certain reservoirs in Germany, as that at Dahlhausen, on the Wappen, and another in the valley of the Bever, which serve very much the same purpose as do those at Furens and Ternay in France, and exercise an important influence upon the floods in their respective valleys. Various similar works have been constructed in other parts of Europe, but all have other motives in addition to that of flood protection to justify their construction.

The systematic creation of a comprehensive system of reservoirs on any river for the sole purpose of mitigating the severity of floods has never been undertaken. The subject has, however, received exhaustive study, and some examples of such studies will therefore be of importance in this connection. By far the most important of these studies, as might have been expected, is to be found in France. It took place during the reign of Emperor Napoleon III, as a result of the floods of 1856. These floods were among the greatest and most destructive that had ever visited France, and aroused a great deal of interest in the question of their future prevention. Among the various proposals which were brought forward at the time was that of constructing reservoirs at the headwaters or on the tributaries of the various streams, among which particular attention was given to the Rhone, Garonne,

and Loire. These investigations were ordered by the Emperor under date of July 19, 1856, and resulted in the most exhaustive analysis of the whole subject and in reports of great scientific value. They embraced the three streams above mentioned, and the result was adverse to the project so far as the Rhone and Garonne were concerned and favorable as to the Loire. A brief résumé of the reports will here be given.

RHONE RIVER.

The damages wrought by the flood of 1856 in the Rhone Valley were extraordinary. Over 540,000 acres of rich valley lands were submerged and the newly started crops were destroyed. The injury to bridges, dikes, revetments, and other river works was very great, as was also the destruction to the towns and cities situated along the stream. The total damages on French soil in the Rhone Valley were estimated at not less than $6,000,000.

So great a disaster in one of the most populous sections of France naturally led to inquiries into the possibility of preventing a recurrence of it. Napoleon III, who had taken a great interest in public works and favored a liberal extension of them, ordered an elaborate investigation of the subject; first, as to the immediate protection of great centers of population, and second, as to the practicability of "modifying the régime of great water courses for the protection of the bottom lands by a diminution of floods by means of reservoirs established near the head waters of the tributary streams."

The first part of the programme, viz, the protection of the river towns by works intended to confine the floods to proper limits, was reported practicable at a total cost of about $4,000,000. The second part of the programme, viz, the question of reservoir construction, was considered in great detail and with a thoroughness of study which makes it the best existing example of what may be expected from similar works in other localities.

The River Rhone has a total length of about 447 miles and a watershed of about 36,670 square miles. Three hundred and thirty-six miles above its mouth is Lake Geneva, an immense natural reservoir, with an area of 223 square miles. Below Lake Geneva, at the distances given, the main stream receives the following important tributaries:

The Arve, 1½ miles below the outlet of the lake, drainage area 2,422 square miles; the Ain, 110 miles, drainage area 1,355 square miles; the Saone, 131 miles, drainage area 11,019 square miles; the Isere, 179 miles, drainage area 4,360 square miles; the Ardeche, 225 miles, drainage area 938 square miles; the Durance, 272 miles, drainage area 5,716 square miles. The drainage area of all the other tributaries is about 7,200 square miles. The drainage area tributary to Lake Geneva of 2,663 square miles, of which 2,078 square miles pertains to the Rhone above the lake.

The flood of 1856 in the valley of the Rhone was practically a simultaneous affair in all parts of the valley. Only in the upper portions was there any apparent progression. The maximum occurred at the mouth of the Arve thirty-six hours before it reached the mouth of the Ain, 108 miles below; but for the entire remainder of the river the maximum occurred on the same day, with a variation of only a few hours. The causes that led to the flood were therefore operating throughout the entire valley, swelling all the tributaries at once, and in consequence causing a simultaneous elevation of all portions of the main stream.

The following table shows some of the characteristics of this flood:

Name of stream.	Drainage area.	Discharge.	Rate of run-off per square mile per second.
	Sq. miles.	*Second-feet.*	
Rhone above the Arve	2,663	11,472	4.3
The Arve	751	24,710	31.0
The Ain and smaller tributaries below Arve	3,777	161,674	43.0
Saone and smaller tributaries below Ain	11,264	49,420	4.0
Isere and smaller streams below Saone	6,079	92,662	15.0
Ardeche and smaller streams below Isere	2,916	80,307	27.0
Durance and smaller streams below Ardeche	7,232	70,600	10.0
Durance to the sea	1,569	.....	.....
Entire river	36,352	490,670	14.0

This table gives an admirable illustration of the effect of natural reservoirs in moderating the flow of a stream. It will be observed that the flow of the Rhone just above the Arve indicates a run-off of only 4.3 cubic feet per second per square mile. As a matter of fact, the upper course of the Rhone was discharging into the lake 42,360 cubic feet per second, or 21 cubic feet per second per square mile, which would indicate for the entire watershed above the Arve, including that of Lake Geneva itself, 56,480 cubic feet per second. The storage of Lake Geneva accounts for the difference, and actually reduces the flow of the upper Rhone by about 45,000 (56,480 — 11,472) cubic feet per second.

Again, it will be seen that the discharge of the great tributary, the Saone, is at a rate of only 4 second-feet per square mile. Although there is no lake forming a reservoir in this valley, as in that just described, the slope of the lower portion of the valley for 100 miles above Lyons is so slight that floods do not pass off rapidly, but fill up the bottoms over 166 square miles to a depth of 10 feet or more, giving a storage of upwards of 50,000,000,000 cubic feet. If the flow of this stream had been as great per square mile of watershed as that of the Rhone above Lyons, without the moderating effect of Lake Geneva, it would have been about 363,000 cubic feet per second instead of its actual flow of about 50,000 cubic feet. Without the storage effects of Lake Geneva and of the Saone Valley, the discharge of the Rhone at Lyons would have been about 600,000 cubic feet instead of its actual discharge of less than 250,000 cubic feet. The great influence of these two natural reservoirs in moderating the flood discharge of the Rhone at Lyons is thus clearly apparent, and it is evident that without them the range between high and low water, or the ratio of minimum to maximum discharge, would be much greater than it actually is. It would not, however, be correct to infer from this that the destructive power of the great floods of the Rhone would, under the above supposition, increase in the same proportion as the discharge itself. Nature adapts the channels of streams to the work required of them, and if the flood flow of this river were greatly increased undoubtedly it would carve out a deeper and wider bed, and would carry away, within the limits of safety, a much larger volume of water than it does at present. Thus, while the absence of these natural reservoirs would, probably, to some extent increase the destructive power of the floods

of the Rhone, it would not do so in anything like the same proportion in which it would augment the flood discharge at Lyons.

When, in the course of their investigations, the French engineers undertook to supplement the effect of these natural reservoirs by artificial ones, they were confronted with practically insuperable obstacles. Nature had not provided suitable localities, and an exhaustive study of the whole basin gave only the following meager results:

Lake Geneva could be so dammed at the outlet as entirely to cut off its discharge at the time of flood.

The Arve and its tributaries, being mostly torrential streams, afford very few good reservoir sites. In fact only one was deemed worthy of consideration, and its capacity was only 706,000,000 cubic feet. This would be of no use to the upper Rhone, which flowed between high banks not subject to overflow, and by the time it reached Lyons its effect would be wholly inappreciable. The reservoir would cost $400,000, besides the destruction of valuable bottom lands. This project was therefore not considered practicable.

The next site in passing downstream is what is known as the Lac du Bourget, situated to the east of the river and forming a kind of natural reservoir in times of flood. It was proposed to carry this natural action still farther by damming the Rhone. Its natural storage capacity is 3,350,000,000 cubic feet, and this could be increased to 5,824,000,000 cubic feet. It was calculated that this storage would diminish the flow of the Rhone at the moment of flood by 35,000 cubic feet per second, and would diminish the height of the flood at Lyons by 2.3 feet. The cost of this work would be about $4,000,000.

No further reservoir sites of importance were found above the junction of the Ain. In this valley there are several feasible sites, whose aggregate capacity would be nearly 2,000,000,000 cubic feet. The cost would be about $1,400,000. The estimated effect at Lyons on a flood like that of 1856 would be to reduce the height of the flood by about 1 foot.

No reservoirs were recommended for the Saone, because none that could be found would have any appreciable effect as compared with the vast natural reservoir formed by the lower part of the valley already alluded to, and would have almost no influence on the discharge of the main stream at Lyons.

Below Lyons the immediate valley of the main stream offers no opportunities for large reservoirs.

The first large tributary on this section of the river, the Isere, was carefully studied, but no situations were found which were considered favorable. The alluvial and unsatisfactory nature of the foundation for dams, the necessity of condemning valuable bottom lands, the small aggregate result possible of attainment under the most favorable circumstances, rendered the project wholly unadvisable.

The valley of the Ardeche likewise contains no feasible reservoir sites.

On none of the other tributaries were suitable sites found until the Durance was reached. The valley of this stream, which is one of the largest affluents of the Rhone, offers several good sites, and it was found practicable to store 11,366,600,000 cubic feet of water at a cost of about $6,600,000. The result, however, was altogether insignificant. The Durance enters the Rhone far down the valley of that stream, where its flood discharge is already very great. The effect of the proposed reservoirs on the flood of the Rhone immediately below the junction would be to diminish its height by less than 1.3 feet.

The following tabular summary shows the magnitude and cost of the foregoing works:

Reservoir.	Capacity.	Cost.
	Cubic feet.	
Lake Geneva	2,294,500,000	$1,000,000
Valley of Arve	706,000,000	400,000
Lake du Bourget	5,824,000,000	4,000,000
Valley of Ain	2,000,000,000	1,400,000
Valley of Durance	11,366,600,000	6,600,000
Total	22,191,100,000	13,400,000

The result of these works and of this expenditure may be summarized as follows:

Over the 24,700 acres of submergible lands the depth of overflow would be reduced from 2.2 to 3.2 feet. But this would not entirely prevent submersion, and the necessity for dikes would exist as before. Through Lyons the flood height would be reduced possibly 3 feet, but would save none of the special works of protection and would but slightly diminish their cost. From Lyons down the diminution of height of flood would be as follows: Below mouth of Saone, 1.3 feet; at Tournon, 0.8 foot; at Valence, 0.6 foot; below Valence, inappreciable. The effect of the proposed reservoirs in the valley of the Durance on the floods of the Rhone below the junction of the two streams would be to diminish the flood height at Beaucaire 1.3 feet; at Arles, about 0.5 foot; below Arles, not at all.

The effect of these reservoirs, therefore, although considerable in absolute magnitude, would not be sufficient, in comparison with their great cost, to justify adoption, and the project was reported upon adversely by the engineers.

This report does not deal with the low-water flow of the Rhone at all, nor with the effect which this storage would have upon the interests of navigation. Undoubtedly it would be much greater than in the control of floods. For example, the 10,000,000,000 cubic feet of water that could be stored upon the Upper Rhone and the Ain would provide a flow of about 4,000 second-feet for one month, or 1,300 second-feet for three months, and could undoubtedly be so regulated as to be of considerable advantage to navigation. The increase for a period of one month only over the low-water flow at Lyons would be nearly 50 per cent.

GARONNE RIVER.

Similar studies to those just described were also made in the case of the Garonne, which had likewise suffered severely from the floods of 1855 and 1856. Without reviewing these studies in detail, the following conclusions may be stated in the language (translated) of the report:

> Reservoirs, when their capacity is great enough, have a very powerful effect in diminishing the flood discharge of the streams on which they are built but their influence diminishes enormously with distance; and inasmuch as suitable sites can be found only in the mountainous regions, far removed from the bottom lands to be protected, it may readily be seen how slight must be their influence on the flood heights in the valleys far below. * * * To reduce such a flood [as that of 1855] to the height required in order to contain it within the proposed system of dikes would require a storage capacity exceeding 33,000,000,000 cubic feet, and would cost $24,000,000. * * *
>
> Other objections of a fundamental character as to all reservoirs have already been stated.
>
> The conclusion arrived at, therefore, is that the idea of reducing the floods of the Garonne by means of artificial reservoirs must be abandoned.

LOIRE RIVER.

The studies devoted to this question in the case of the River Loire were more favorable to the use of reservoirs. This was owing to the more favorable conditions which prevail on that stream. The main stream is formed by the union of the Upper Loire and the Allier near the city of Nevers at the Bec d'Allier. The Loire is subject to the most extreme variations in the matter of flow. At the junction of the two streams, for instance, it varies from about 10,000 cubic feet per second to 350,000 cubic feet. The floods in the lower river are ordinarily rendered harmless by the arrival, at different times, of the floods from the various affluents; but when the conditions cause the simultaneous arrival of flood crests from several tributaries the results are liable to be of the most serious character.

The floods of the Loire River have always been a matter of great moment to the interests of the valley, and have led to extensive works for their control. In the studies above referred to the use of reservoirs on certain portions of the streams was recommended, viz, upon the Upper Loire and the Allier. These two streams, heading in the south-central part of France, flow north nearly parallel to each other at distances scarcely ever 50 miles apart. Their drainage areas are 7,000 square miles and 4,500 square miles, respectively. The geographical, geological, and meteorological conditions are essentially the same for the two streams. They rise in high land some 4,500 feet above the level of the sea. The mountain slopes are steep and the soil of a very impervious character. The result is that the run-off responds quickly to the rainfall; floods are quick and of short duration, and the curve of the flood wave at any point is sharp in character, i. e., very high compared with its length. The conditions in the two valleys are so similar that the crests of floods reach the junction very nearly at the same time, being only two or three hours apart in the great flood of 1856. The curves of discharge of the two streams, both accentuated in character, are superimposed upon each other, producing a curve of relatively the same relief, but absolutely nearly twice as pronounced, as in the case of either tributary.

The union of two such considerable tributaries with floods of the nature above described gives character to the flood wave of the united stream for a great distance below, or until the accession of tributaries reaches an extent that may exert a marked modifying influence. But it is stated that the sharp form of the wave does not entirely disappear even to the mouth of the river.

The flood conditions, therefore, prevailing from Nevers for a long distance down are those of extreme height but short duration. Were it possible to cut off the upper part of this curve and retain the water which it represents, thus reducing the flood curve to the normal form of the other principal tributaries, the floods would be brought within limits which would keep them between the dikes proposed to be constructed along the river.

An examination of the valleys of the Upper Loire and the Allier disclosed the following possibilities as to the storage of water:

In the valley of the Upper Loire 22 reservoirs would store about 8,250,000,000 cubic feet of water, and would reduce to 111,653 cubic feet per second the flood flow, which, without these reservoirs, would be 153,555 cubic feet per second at Bec d'Allier. In the valley of the Allier 63 reservoirs, storing about 10,000,000,000 cubic feet, would reduce to 104,664 cubic feet per second the flood flow, which, without the reservoirs, would be 167,675 cubic feet per second. The total reduc-

tion would therefore be about 95,000 cubic feet per second from a total flood flow of 320,000 cubic feet per second, or a reduction of about 30 per cent. This would deprive floods of their destructive character as far down as to the mouth of the Cher, a distance of about 180 miles below the junction of the two streams.

It is thus seen that the peculiarly favorable conditions existing on the Upper Loire make possible an important reduction of flood height for a certain length of the river below Nevers. In the upper valleys, near the reservoirs, their effect would, of course, be far greater, and would effectually remove the possibility of flood.

These proposed works, however, were of great magnitude, estimated to cost over $13,000,000, and they have never been carried out.

A very interesting and exhaustive investigation, similar to those just described, has been conducted by German authorities in the valley of the river Alb. The study goes into too much detail to be given here, but its general conclusions are so in line with those of the French engineers that they can not fail to be of interest. The report says:

> It can not be denied that for the headwaters of rivers, and also for the territory of small streams, the question might be solved. The Government of Wurtemburg investigated the matter and found that high floods could be prevented by means of reservoirs, but that the benefit would not be commensurate with the cost. * * * This investigation [the prevention of floods on the Alb] has proved that the construction of reservoirs for the purpose of keeping back the high water of the Alb, although possible, and with no doubt of their effectiveness, is still unjustifiable on account of the enormous cost.

And again:

> There seems to be no doubt that the construction of a system of reservoirs on a large scale in the valley of the Alb is inexpedient, on account of the great cost.

Particular emphasis is placed upon these studies, because they disclose the true obstacle to the use of reservoirs for the sole purpose of flood prevention. It is the *cost*, not the physical difficulties, which stands in the way. It may be stated that as a general rule a sufficient amount of storage can be artificially created in the valley of any stream to rob its floods of their destructive character; but it is equally true that the benefits to be gained will not ordinarily justify the cost.

The reason for this is plain. Floods are only *occasional* calamities at worst. Probably on the majority of streams destructive floods do not occur, on the average, oftener than once in five years. Every reservoir built for the purpose of flood protection alone would mean the dedication of so much land to a condition of permanent overflow in order that three or four times as much might be redeemed from occasional overflow. One acre permanently inundated to rescue three or four acres from inundation of a few weeks once in three or four years, and this at a great cost, could not be considered a wise proceeding, no matter how practicable it might be from engineering considerations alone. The cost, coupled with the loss of so much land to industrial uses, would be far greater than that of levees or other methods of flood protection.

In fact, the examples of natural reservoirs already cited, while they show conclusively the vast beneficial influence of large reservoirs upon the flow of streams, also disclose the fatal obstacle to their successful imitation by man. In only very few places has nature prepared sites where man can erect works which will create large bodies of water, and even if she had done so the gain from utilizing them would not equal the loss. The reservoir system of the Great Lakes involves the perpetual withdrawal from agriculture and industrial uses of an area nearly twice the size of the State of New York. Were these areas not

covered with water, but occupied as the surrounding country now is, yet so fitted by nature that man, at slight expense, could convert them into great lakes, as at present, the utter impossibility of such a measure is evident at a glance. And so it will be found in general that the surface of the earth, where reservoirs could be built on an extensive scale, is liable to be of more value in its present condition than it ever could be if covered with water.

The construction of reservoirs for flood protection is not, therefore, to be expected, except where the reservoir is to serve some other purpose as well, and inasmuch as such purposes are not ordinarily extensive enough to develop *systems* of reservoirs, upon which, rather than upon isolated works, the control of great floods depends, this large control is hardly one of the possibilities of the future. The only probable exception is that of a reservoir system on the watershed of the Missouri River, treated of in the next section of this report.

For flood protection in isolated cases, however, and on a relatively small scale, reservoirs will undoubtedly continue to be built, particularly when they serve other purposes as well. From this point of view they will always be projects of public importance. The idea is well presented by the distinguished French engineer, P. Guillemaine, former inspector-general of public works in France, who holds that the creation of reservoirs is of public utility in nearly all cases, either in flood prevention or in reenforcing low-water flow, and that whenever special interests, such as industrial uses, irrigation, and the like, exist that will justify their construction, they become legitimate subjects for government adoption.

XIV.—THE FLOODS OF THE MISSISSIPPI AND THE MISSOURI.

The wording of the act directing this investigation, and the debates in Congress accompanying its passage, clearly indicate that the floods of the Mississippi and their prevention were in mind as one of the objects of the proposed reservoir construction. A belief that it is within the range of possibility to diminish materially the great floods of this river by means of reservoirs upon its tributaries has long been held. In a work well known in its day (The Mississippi and Ohio Rivers, by Charles Ellet, jr., published in 1853), the author advocates this view with great vigor, and had his data been as correct as his argument he would have made out a good case. The subject was briefly reviewed by Humphreys and Abbot in their report upon the Mississippi River (1861), and the views of foreign engineers upon this method of river regulation were cited at considerable length. Although the authors of this report pronounce the scheme impracticable so far as the Mississippi is concerned, the idea has, nevertheless, continued to have its advocates from that day to this. It has occasionally found expression in public documents or acts of Congress. In the voluminous report of the Senate Committee on Irrigation, which forms Senate Report No. 928, Fifty-first Congress, first session, the committee say:

> It is confidently believed that, with restraining dams to hold back the water of the numerous lakes found at the head waters of the various tributaries of these rivers, and reservoirs constructed at other suitable points, together with the aid of the natural flow of the streams, a very large extent of country, now comparatively worthless, could be made exceedingly productive, while the floods in the Lower Mississippi would be greatly alleviated.

During the past year two investigations have been ordered by Congress, having as one of their objects an examination of this reservoir

question. Among engineers there are not a few of reputable standing in their profession who hold similar views to those expressed in the Senate report quoted above. With the general public the idea is almost an axiom, and it finds constant expression in the press, particularly when a great occasion, like that of the recent Mississippi floods, calls attention to it. It has therefore seemed important in this report to devote some especial care to the subject, and very soon after taking up the study I arranged to have Mr. James A. Seddon, United States assistant engineer, compile existing data on the Mississippi floods in such form as to present the subject in its entire magnitude so that it can be readily understood. Mr. Seddon has executed this task with a thoroughness which I do not think has been surpassed in any similar investigation. He has relied largely upon graphical representation of his data, and for this purpose has prepared two plates, one for the rivers above Cairo and one for the river below. These two plates present in the most intelligible manner possible the movements, characteristics and magnitudes of these great floods. They merit careful study, and will be found of great practical value to anyone who may have occasion to study the question. Mr. Seddon has accompained these plates by an exhaustive memoir, in which he explains in detail the method of their preparation and summarizes concisely the conclusions to be drawn from them. To this work of Mr. Seddon I invite particular attention, as it relieves this part of my report of considerable matter which it would otherwise have to contain.

Few people have any adequate conception of either the origin or the magnitude of great floods like those on the Lower Mississippi. It is a common error to think that they come largely from the melting snows in the mountains. Yet the floods of the Mississippi nearly all come at seasons when the flow from the mountains is very small. In the greatest known flood of the Mississippi at St. Louis, that of 1844, a large part of which came from the Missouri, the latter stream was found by pilots to be in low-water stage above Sioux City. On the occasion of the late heavy flood in the Mississippi, when at its maximum stage, the Arkansas carried practically no water across the Kansas-Colorado line, the Platte did not run above 2,000 cubic feet per second at North Platte, Nebr., and the Upper Missouri and Yellowstone were both in low-water stage. The floods of the Mississippi do not come from this direction. They are formed by the heavy rains in the low regions east of the ninety-eighth meridian, and very largely come from east of the Mississippi itself. The great controlling element, in fact, in all the lower river floods is the Ohio River.

The magnitude of these floods also depends very largely upon fortuitous combinations of the floods in its tributaries. No single flood from any one of these tributaries, except the Ohio, can produce serious consequences in the main river. But if two or more of them discharge excessive floods in the main stream simultaneously, then it is that great disasters follow. Very fortunately, nature has caused these flood waves to arrive generally at different periods, and the more disastrous combinations are not of frequent occurrence.

It is apparent, therefore, that a reservoir system which should exercise any appreciable influence on the lower-river floods must embrace the three great upper tributaries, and particularly the Ohio. What the magnitude of the storage required would have to be may be inferred from the fact that the total discharge of the Mississippi at Cairo above the bankful stage, during the late flood, was 2,368,000,000,000 cubic feet, or 4,250 square miles 20 feet deep, the assumed average depth of

reservoirs. The largest artificial reservoir ever built—viz, that at Lake Winnebigoshish, Minnesota—has a capacity of 45,000,000,000 cubic feet. To store all this excess would take 52 such reservoirs.

While it might seem at first thought that this amount of storage could be found, still it would be very difficult to find it. Particularly on the upper Ohio and its southern tributaries favorable sites are understood to be of rare occurrence. It is probable, however, that in all the watershed of the Mississippi sites could be found that would insure a reduction of a flood discharge at Cairo like that of 1897 by one-fifth of its maximum. The ease with which the writer was able to find storage amounting to 11,000,000,000 cubic feet in the State of Ohio at the very headwaters of streams along the divide between Lake Erie and the Ohio convinced him that the natural facilities for storage are rather greater than is commonly supposed.*

As already stated, the difficulty is not so much a physical as a financial one. To store, say, 500,000,000,000 cubic feet of water, equivalent to 11,500,000 acre-feet, would cost, even at the rate of only $5 per acre-foot, $57,500,000. This one fact condemns the project as a system for the exclusive purpose of flood prevention. But whenever such reservoirs have other and more immediate purposes for their construction the increment which each will form in the grand total necessary to produce some influence in the Mississippi floods is an element in its favor worthy of consideration.

The only direct and effective reservoir project, if any such be possible, for impounding floods of such vast magnitude as those of the Mississippi is that pointed out by Mr. Seddon in the second part of his memoir. The project for utilizing St. Francis Basin for this purpose would only be following out and perfecting the plan upon which nature has operated for an indefinite period. If the overflow into this basin in a great flood like that of 1882 is equivalent to a depth of 6.5 to 7 feet upon its overflowed area of 6,706 square miles, it is at least a reasonable question to ask why this flooded area can not be reduced to one-half or one-third its present size, be given a depth twice or three times as great, and the water be prevented from flowing out until the following low water. The slope of 120 feet in the length of the basin would seem to make possible a division into separate reservoirs by means of moderate embankments such as Mr. Seddon suggests, making five or six basins of an average depth of 10 to 15 feet, with longitudinal levees to restrict the lateral area. The water thus stored (and it could be stored with such an arrangement, whether there were a high flood or only a moderate one) would give to the lower river in low water an increment (based upon the overflow of 1882) of 141,000 cubic feet per second for a period of one hundred days. This would give a low-water flow of at least 300,000 cubic feet per second, and would radically improve the navigation of the Mississippi from Helena to the sea. From Helena up, the slackwater system through the basin itself, with 5 or 6 locks, would carry the deep water to Cairo. How far the imperfectly known topography of the St. Francis Basin would lend itself to this project, and whether or not the cost would be prohibitory, exhaustive surveys alone can tell. But the example which nature has set in the use of this basin is at least *a priori* evidence in favor of the soundness of Mr. Seddon's suggestions.

On the Missouri River the case with regard to reservoirs is somewhat

* See report on Ohio Canal surveys in 1895, House Doc. No. 278, Fifty-fourth Cong., first session, p. 56; printed also in Annual Report of the Chief of Engineers for 1896, part 5, p. 2973 et seq.

different. The annual flood of that stream, which is known as the "June rise," is essentially a headwater flood. The earlier floods are generally, although not always, from the lower river, and very rarely from the extreme upper sources. The June rise is the mountain flood, bringing down the snow water, and generally augmented by the spring rains both in the mountains and on the plains below. Not infrequently it meets with heavy contributions all the way down, and is the result of a general high water over all its drainage area. Ordinarily, however, as already stated, it is a headwater flood, and coming as it does while the banks are still soft and yielding from previous high water, it does its full share of the destructive work peculiar to the Missouri River.

That a complete system of reservoirs in the mountains and plains portion of the watershed of this stream, which should embrace its many tributaries and contain the waters from melting snows and spring rains, would materially reduce the magnitude of the June rise is highly probable. To take off the flood excesses at Sioux City, mentioned by Mr. Seddon in the first section of his memoir, would require a storage of, say, 48,400,000,000 cubic feet, corresponding to a reduction in stage of 2.8 feet. A storage of 100,000,000,000 would probably give the very material reduction of 6 feet. Allowing a reservoir efficiency of only 50 per cent, as elsewhere explained, and assuming that no one of the great floods of the Missouri has its origin in more than one-half of its watershed, it would seem that a reservoir system of 400,000,000,000 cubic feet, distributed over the watershed above Sioux City, would quite effectually control the floods of the river. This amount of storage is about the percentage of total flow required to be stored for irrigation, as hereafter explained, in order that the water of the arid region may be fully utilized. It must be understood that such a result can be predicted only from a *system* of reservoirs. The effect of any single reservoir would certainly be insignificant, but the combined influence of many might be very important.

Passing now to the question whether the benefits to the lower river from such a system would be of sufficient importance to justify the construction of reservoirs solely for the purpose of securing them, the answer must be distinctly in the negative. It is still true in this case, as in those already considered, that the benefit is not worth the cost. If, however, there are other and primary considerations, which of themselves would justify the construction of reservoirs, then their influence upon the floods of the lower river is a matter worthy of consideration. And when such primary interests are of a magnitude which looks to a comprehensive system throughout the watershed of the stream, subserving interests of a public as well as a private nature, then the argument for Government assistance in such works stands upon a substantial basis. The point to be especially considered, in connection with such a reservoir system, is that river regulation must always be a secondary motive and more immediate and direct uses the primary motive.

XV.—RESERVOIRS IN THE ARID REGION.

We now come to the specific question of reservoir construction in the arid region west of the one hundredth meridian, as exemplified by the reservoir sites examined in Wyoming and Colorado. Are there direct and primary motives which would justify reservoir construction in this country, apart from or in addition to those arising from their effect upon the regimen of the lower rivers? The answer must be that in no other part of the United States, nor anywhere else in the world, are

there such potent and conclusive reasons, of a public as well as a private nature, for the construction of a comprehensive reservoir system as in the region here in question.

It is not intended in this report to enter at all into the subject of irrigation. That subject has been exhaustively treated for many years in public reports, and the mass of official literature relating to it is so great that anything further in that line would be superfluous. It will be referred to here only to show its supreme influence in the reservoir problem of the Far West. Of the very great importance of irrigation, not only to the West but to the country at large, there would seem to be no room for doubt. To one who has seen the changes wrought in the once desert regions of California, Arizona, Utah, Wyoming, and Colorado, in what used to be as forbidding regions as any still remaining in that country, there can be no doubt that the destiny of the arid section of America is more dependent upon the waters that flow from its mountains than upon the minerals that lie concealed within them. Already in the greatest mineral-producing States of the West, California and Colorado, irrigated agriculture yields a greater wealth of product than the mines. It is easy to point out many valleys in the arid regions the future development of which, under irrigation, will sustain in each a population greater than that at present is to be found in the States where they are located. There can be scarcely a doubt that the ultimate extent of this development is limited only by the capacity of the streams, and the vital and controlling function of these streams in the future welfare of a vast extent of the national domain is a matter too obvious to require demonstration.

But to utilize fully this element of national growth something more must be done than to take these streams as nature has created them. Already in many sections the natural flow has been used as far as it is practicable to do so. The only resource left is to store that portion of the flow that runs away in nonirrigation seasons and the surplus in times of annual flood and sudden freshets and make these also available for use. Not until that is done can a stream be said to be really utilized to the fullest extent.

Here, then, is a definite reason of the highest validity for the construction of reservoirs. It is of itself a sufficient reason, without any reference to the incidental benefits to the streams below.

Another particular and definite reason is flood protection along the streams immediately below the reservoirs. The destructive power of mountain floods is sometimes very great, and damages of vast amount have been wrought by them. The damage from these mountain floods will, of course, increase with the settlement of the country. Well-built, capacious reservoirs are an almost complete protection against such floods, and their usefulness in this respect will be an important consideration in their favor.

While there are these clear and positive arguments in favor of the storage of the surplus flow of our Western streams, there are none of weight against it. It may be set down as a rule, to which there are very few exceptions, that every artificial body of water created in the West, by which the surplus water of its streams is held back, will be a positive benefit. There are some who even go so far as to think that the influence of these stored waters, which would cause the streams to return to vapor in the near locality of their origin instead of flowing down to the sea, would have a marked beneficial effect upon the rate of precipitation in the West.

The inevitable tendency of Western development is therefore to store

the waters of the streams, and the limit of development in this direction seems certainly to be nothing less than the final utilization of all their flow. As reservoirs are indispensable aids to this end, it will be seen that their construction as an element of growth of the Western country is not merely "desirable"—it is absolutely necessary. The only question in this connection that admits of doubt or uncertainty is, What is the proper agency to do the work?

XVI.—RESERVOIR CONSTRUCTION IN THE ARID REGIONS.

HOW CAN IT BE BEST ACCOMPLISHED?

Reservoir construction in the West can be accomplished by any of five agencies, or by all together. Two of these are of a private nature, viz, private individuals and companies or corporations. The other three are of a public nature and are irrigation districts, the States, and the General Government. Let these several agencies be considered in the above order.

PRIVATE INDIVIDUALS.

It is easy to see that reservoir construction can not be carried on single handed by individuals except upon a very limited scale. When a reservoir is built upon any site it is important that the capacity of the site and the stream be fully developed. But such works are ordinarily very expensive. Even if the financial resources of the individual would permit the construction, the use he could make of it afterwards would probably not require as large a reservoir as could be built, and he certainly could not be expected to build for the benefit of others. The result would be that very few works of magnitude would be commenced at all and those commenced would probably not be what the true capacity of the sites would call for. Again, it is wholly improbable that works so built, looking only to immediate returns upon investments, would be of that permanent and enduring character which it is greatly to be desired that they should possess.

The same argument, in a less degree, applies to corporate management of these works. In the matter of financial requirement the problem could possibly be solved in this way. But no investment is feasible unless the investor can control the property of which it is made the subject. Now, water is perhaps the most elusive of all forms of property. The owner must not only control the source of supply, but the place of application as well. If it be the supply of a city and a company has secured its monopoly, if it be a canal, or if it be a definite site for the development of water power, then the difficulties of the situation are reduced to a minimum. But when it comes to applying water to land the case is different. To insure a remunerative use of the water supply it is necessary to control the land where it is to be applied. There are several examples in the more limited valleys of the short coast streams of California where this has been done with some measure of success. But one has only to examine the history of these works, and consider the vast amount of financial failure which has accompanied them, and the interminable litigation to which they have given rise, to see that even in this favorable section the method has been far from an unqualified success. There are doubtless few people in California to-day who will not admit that it would have been better if these works could all have been constructed under some sort of public control. When it comes to other sections of the country the conditions would

be still more unfavorable. In Wyoming the policy of small holdings is far better established than in California. Corporate control of large areas is more difficult, and the streams are of such length, and the benefits of the sources of supply reach so far, that it would be impossible to control them all.

The reservoir sites considered in this report are good examples. In the case of the South Platte site in Colorado, the value of this reservoir for water power might, owing to its proximity to a great industrial center of population, be sufficient to justify its construction; but even here the company could not realize the legitimate fruit of its labors, for the water would flow on to sections over which it would have no control and be used over and over again in irrigation. The Loveland site would seem to be especially favorable for a paying investment, since it lies in the heart of a rich agricultural section where every foot of its supply could and would be profitably used. But I was told by Professor Carpenter, of the State Agricultural College of Colorado, that the difficulties in the way of developing this site, based upon the drawback above noted, are such that private investors can not safely take hold of it. In the other localities the matter presents even greater difficulties. The waters of the Piney flow through not only the Piney Valley itself, but have been turned in part across from the Powder River watershed into that of Tongue River and ramify in an almost endless series of ditches. It would seem to be an impossible problem to build these reservoirs as an investment scheme pure and simple. The storage of the Sweetwater site will be used over so vast an extent of territory that any effective control of it is absolutely out of the question. In the case of the Laramie a storage project of less pretentious magnitude has been thought of by the Wyoming Development Company, which controls considerable areas of land near Wheatland, Wyo.; but I do not understand that even this project would justify a storage scheme such as would really develop the full resources of the Laramie rivers.

The matter of private or corporate construction of these storage works is therefore seen to be one of very doubtful practicability from a financial view alone, while in neither case is it likely that reservoir sites would be developed to their full capacity, as they should be, but only to the extent that would be most advantageous to the investment itself. The result would be, from a public point of view, an incomplete and imperfect system.

There is another view of great public importance which also tends in the same direction. It is becoming more and more apparent in the course of irrigation development in the West that the waters of the streams should not be made the subject of private property, but that they should inhere in the land to which they are applied, and that purchase or sale of water as a commodity should not be allowed. Although in most States the contrary doctrine has hitherto prevailed, the disposition of the courts at present and the views of practical irrigators seem to incline more and more to the doctrine of the public character of all streams. In one State, Wyoming, this more enlightened doctrine has gained a secure foothold, and the entire administration of the water laws is based upon it. That State has profited by the mistakes of others, and although great pressure has been exerted in favor of the opposing doctrine, it has not yet yielded in a single point. It is clear that this principle can best be promoted, so far as stored waters are concerned, by having the storage works public property. Their construction by private agencies is hardly separable from the control and disposition of the water as a commodity.

A proper development of a storage system for the waters of Western streams, it is thus seen, can not be expected through private agencies. It must be accomplished through some form of public control.

IRRIGATION DISTRICTS.

Irrigation districts would seem theoretically to present very many of the advantages to be expected from the public construction of storage works. They are designed to enable the residents of a particular section of country, which is naturally watered by a common stream or source of supply, to organize for mutual promotion of irrigation enterprises in the development of its lands. As exemplified by the celebrated Wright law of California, such a community, by complying with certain conditions, can form a district, issue bonds, construct reservoirs, ditches, and other irrigation works, and the bonds therefor become a first lien upon the real property of the district. The powers thus granted are seen to be almost those of sovereignty, while the territorial restrictions limit districts to territory in which the interests to be promoted are as similar as can possibly be secured. The law is, a priori, an admirable invention to secure a public administration of irrigation works, and is one from which great results would naturally be expected.

But the history of the measure has thus far been distinctly the reverse. Districts were injudiciously and even fraudulently created. Works were entered upon without proper professional information and were frequently found inadequate to the uses required of them. In many cases visionary and worthless projects were put through at the instigation of contractors and promoters, who expected to profit thereby. Some districts were formed where the judgment of a majority of the property owners was against it, and in many other respects the operation of the law was almost a disgrace to the State. The irrigation bonds of course quickly responded to the influence of the system. They depreciated in value, so that disposition of them was impossible on any reasonable terms. Stagnation of work ensued, and many districts were left with a heavy bonded indebtedness, a first lien upon the lands, and no irrigation works to show for it. The system has been emphatically a great disappointment in its practical workings thus far, and although the correction of some of its obvious defects will improve its operations in the future, it will not be easy to rehabilitate it in the public confidence.

But it is clear that however much the district system may be improved in its application to distribution works, it can not develop a comprehensive system of reservoirs. In the first place, it will naturally limit its enterprise in any case to the need of a district. A comprehensive work, which should consider the full capacity of the site and make of it all that it was capable of, could not be expected. A district would not, of course, build for the benefit of others. Add to this that the resources of the districts would necessitate the strictest curtailment of expenses and would rarely permit the scale of expenditure which the best results would require, and it is readily seen that this form of public control of reservoir works would not produce the best results.

STATE OR NATION.

There remain to be considered the States and the Federal Government as the only agencies qualified to create a comprehensive reservoir system in the West. In many respects the arguments which apply to

Federal control of these works apply equally to State control. In each case the agency is in the broadest sense a public one, each being within its proper sphere the sovereign power of the people, deriving its revenues from general taxation, without regard to the special purpose to which the revenue is applied. It will, therefore, only be necessary here to inquire which of the two will be most likely to produce effective results.

In the first place, the work is distinctly interstate in character, and is, therefore, less properly a State than a national enterprise. In scarcely any State except those on the Pacific Coast are the streams confined to limits of the States. Wyoming, for example, is the fountain head of streams that flow to every point of the compass and traverse or border upon no fewer than twenty other States or Territories. The same is true in a less degree of Colorado. There is no reservoir that can be built in either of these States the influence of which will not cross its borders and be felt in other States. With a comprehensive system of reservoirs this matter would become one of great importance, and the continued settlement of the country and the progressive utilization of the streams will render it one of perpetual concern to the public. Already the interstate character of some of these streams is giving rise to troublesome questions, which only Federal authority can answer. Nebraska has complained of the monoply of the waters of the South Platte by the State of Colorado. Irrigators in Wyoming have felt the drain on the river Laramie by Colorado parties, who have turned away into their own streams, just south of the border, a considerable percentage of its flow. There have been complaints in Utah over appropriation by the State of Wyoming of the waters of Bear River, already claimed by Utah irrigators. That more of these questions have not already arisen is only because the natural flow of the streams has not yet been all used up. So long as there is water enough, of course there will be no serious complaint.

In the case of reservoirs it not infrequently happens that some of the very best sites are to be found close to State lines, where the waters so stored will flow immediately into neighboring States. In these extreme cases the States where they are located could not, of course, be expected to construct reservoirs, and the States to be benefited would not be likely to go outside their own borders to do so. The function clearly pertains to that sovereignty which covers all the country and embraces the streams from their sources to the sea. It alone can store these waters and be sure that it is reaping the full benefit.

The policy of the Government in the matter of the preservation of the forests of the country is a case directly in point. There seems to be a well-nigh universal consensus of opinion that the preservation of the forests of the arid regions is distinctly a Government duty. Considerable appropriations have been made for the surveys of proposed reservations, and ways and means for their preservation are being considered. Now, one of the great arguments always advanced in favor of forest preservation is the influence which forests are supposed to have in conserving the flow of the streams. Inasmuch as the commercial value of these forests is practically insignificant, except for furnishing fuel and rough timber, the water question is really the more important one. If it is properly a Government function to preserve the forests in order to conserve the flow of the streams, surely it can not be less a Government function to execute works which will conserve that flow even more positively and directly. Granting

all that can be said of forests in this connection, they certainly can never prevent the June rise, and it is precisely this waste flow which reservoirs will help to save. The forests ought unquestionably to be preserved, and the Government is the proper agency to do it, but the principal arguments therefor apply with accentuated force to the construction of reservoirs.

Another reason why the Government should have an interest in this work is that it is the largest landowner in the arid west. In Wyoming, over 90 per cent of the soil belongs to the Government, and its holdings throughout the West include millions of acres which can be reclaimed from their present desert condition and made productive lands. In this respect, Government assistance in providing water for irrigation is a simple business proposition for the enhancement of its own property.

In the matter of resources, we at once encounter an insuperable obstacle to extensive public works on the part of most of the States. Their revenues will not permit it. In some States taxation is limited by the constitution to certain percentage of valuation. The State in such a case, if without sufficient revenue, is absolutely forestalled from carrying on works which might enhance the value of property in the State and lead to increased revenue. There is no discoverable method by which adequate means can be obtained for State works of any magnitude at this stage of their development unless, as urged by some, it be through a gift to the States of the public lands within their borders. As this is a matter of vital importance, not only to the future development of the West, but to the particular question with which we are here concerned, a brief reference to it will be given.

In order to facilitate the development of the country under the rapidly changing industrial conditions of the West, and particularly to provide the States with an increased revenue, it is being strongly urged in various quarters that the public lands be ceded to the States. It is then proposed to use the nonirrigable lands, which are only fit for grazing, in connection with irrigable lands, so that the holder of irrigable land upon any stream may hold also a good extent of grazing land contiguous thereto, and that the grazing lands of the West may be so divided that every portion shall have access to water somewhere. The free-range industry is practically a thing of the past, and is, by its very nature, incompatible with the permanent settlement of the country. Since the latter is bound to come about sooner or later, a division of the grazing lands would seem to be a necessity of the near future, and the public-land laws will have to be modified to secure this end. It is argued that if the lands are ceded to the States under proper restriction they can be leased at a small rental (1 cent per annum per acre has been suggested), and the States can thus derive enough revenue to enable them to undertake the works in question. Prof. Elwood Mead, State engineer of Wyoming, estimates* that the revenue from this source in the State of Wyoming would be $500,000. Of the soundness of this view as to the proper distribution of the public lands it is not essential to the purposes of this report to speak. The ends sought to be attained by it are undoubtedly necessary to the welfare of that section of the country, and it is greatly to be desired that the Government will assist in bringing them about. If it will not cede the lands to the States outright, it could at least pass laws to facilitate their proper disposition under existing conditions, and it could aid in the construction of those

*The Arid Public Lands—Their Reclamation, Management, and Disposal. Read before the American Society of Irrigation Engineers at Denver, Colo., December 11, 1896.

public works of national importance which the deficient revenues of the States prevent them from undertaking.*

In the course of my investigations I have found a well-nigh unanimous public sentiment in favor of Government aid in the construction of these important works. Such adverse opinions as I have encountered have been based almost entirely upon the assumption that the project contemplates Government control of irrigation works. This I do not understand to be the case at all. If it were it would certainly be a conclusive objection to the whole scheme. The time was, some fifteen or twenty years ago, when the inauguration of a comprehensive policy by the Government for the development of irrigation in the arid regions might have been productive of much good; but that opportunity has passed. The States have taken up the work and the whole system is now built up under State laws, interpreted by State courts, and administered by State officials. There is no reason to think that this is not the best possible arrangement. The States occupy the place in matters of this sort which, in foreign countries, as India, France, Canada, etc., is occupied by the Government. A corps of trained engineers has grown up in the West as fully qualified in every respect for their work as the profession affords. The works themselves are strictly local, confined to the people of the State, and only very rare instances concerning any others. So far as distributing systems, water rights, etc., are concerned, it is in every way better, in fact indispensable, to have these matters entirely in the hands of the States. The results of my investigations have shown nothing else more clearly, and this report must not be construed as in any way indorsing the project of Government control of irrigation works. In only one case can there be any ground for asking Government aid in the construction of distributing systems. If it ever becomes advisable to attempt to turn the waters of the larger streams over great extents of country, involving the construction of canals, perhaps hundreds of miles long, and passing from one State to another, then the magnitude and interstate character of the work might give it a claim to consideration by the General Government.

In the matter of storage reservoirs the case is entirely different. Their purpose is simply to enlarge and reenforce the natural resources of the streams, leaving the use of their waters to be disposed of exactly as at present—unless indeed, an occasional exercise of control were necessary in times of flood or other emergency. The works are not solely of local importance, but have an interstate character. The case is in every respect like that of the Government control and preservation of forests, to which attention has already been called.

Another objection to Government construction which I have met with is based upon the idea that no such work ought to be constructed unless it will clearly pay a good return upon its cost, and it is urged that in such a case private capital itself would take up the work. Two errors underlie this argument. In the first place, a work may be a justifiable and profitable one from a public point of view when it would not be so at all as a private investment. As already explained, the benefits which a reservoir may give rise to are generally not capable of such control as will give a revenue from them. The example of the proposed South Platte Reservoir has already been cited. The water from this reservoir, as it descends from the mountains, 6,840 feet above sea level, may be used first for water power in that important

*It may be of interest to know that in the only instance where State aid has been given to reservoir construction, the experiment has been a confessed failure. (See copy of letter from Mr. Horace A. Sumner, ex-State engineer of Colorado, which is appended to this report. Appendix E.)

industrial center. It may also be used for municipal purposes in Denver and other towns. It will then be put out upon the fields below and be used in irrigation. That portion returning in seepage (about 30 per cent) may be used over again. In flood time the flow of the stream is held back and withdraws so much from the high water of the lower rivers. Now, a private company might turn some one of these uses to account, but never all of them. The Government would reap the benefit of all, for it does not seek its return in the form of levy or toll, but in the general enrichment of the people and increase of national wealth. Judged, therefore, by the mere question of dollars and cents, a work may be entirely justifiable as a public enterprise which would be ruinous as a private investment.

The other error involves a fundamental misconception of the aim and purpose of public works. It should be remembered that the works herein proposed are of the most substantial and enduring character. River improvements, fortifications, public buildings, and the like are liable to destruction and decay, but a mass of earth or masonry properly placed in a great dam becomes as lasting as the hills which inclose it. Constructed to endure for all time, the benefits which flow from these works will be perpetual. It is not for the Government, therefore, with its lease of life altogether beyond that of an individual or company, to limit its expense as an individual would to the certainty of entire reimbursement within a few years. When it improves a site, it should improve it once for all to its full capacity with the most thorough and substantial workmanship, making the work final and complete, being certain that the heavy first expense will be ultimate economy.

The foregoing examination has led up to the following conclusions:

First. A comprehensive reservoir system in the arid regions of the United States is absolutely essential to the future welfare of this portion of the national domain.

Second. It is not possible to secure the best development of such a system except through the agency of the General Government.

Thus far the question of the "practicability and desirability" of Government patronage of these works admits of a definite answer in the affirmative. As to the questions of public policy involved in such a step, it is assumed that their consideration was not intended to be embraced in this report.

XVII.—PRACTICAL WORKINGS.

Before entering upon any work of construction, the Government should acquire full title to the site of the reservoir and accessory works. It should secure cession by the State of jurisdiction to the site, so as to release the land from taxation and other regulations pertaining to the local government. It should also obtain a right to the streams for filling the reservoir, so far at least as to preclude others from interfering with the uses for which it is built. It should then construct the work itself, and not by subsidy or donation either to the State or private parties. It should hold and maintain the work after construction just as it does its other public works. The use of the waters so stored should be absolutely free to the people forever, just as the canals, harbors, and other public works are free for general use without toll or levy of any kind. The Government should have the right to close the reservoirs in times of flood, and to exercise any other control which might be deemed essential to the public welfare on the streams in the valleys below. Subject to these conditions, the waters of the reservoirs should be available for irrigation, municipal, or other industrial uses, and

Diagram Illustrating Percentage of Water Required to be Stored in order that the Entire Flow of a Stream may be used in Irrigation.

Fig. 1.

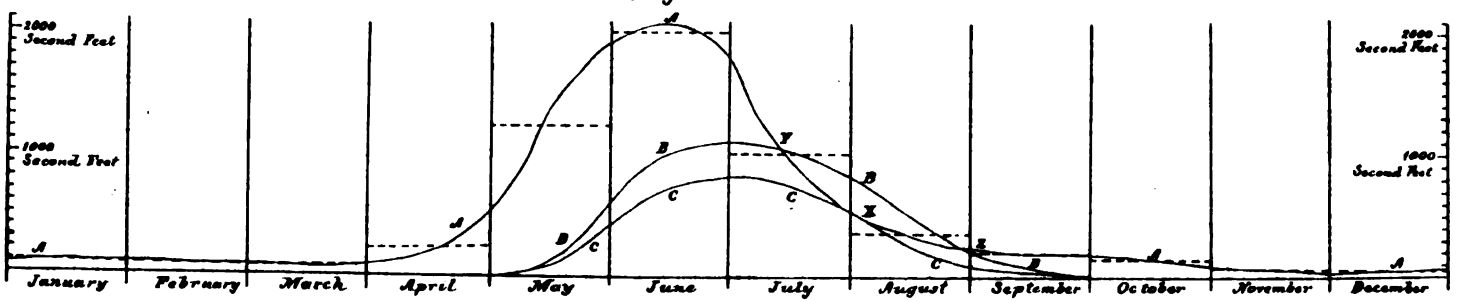
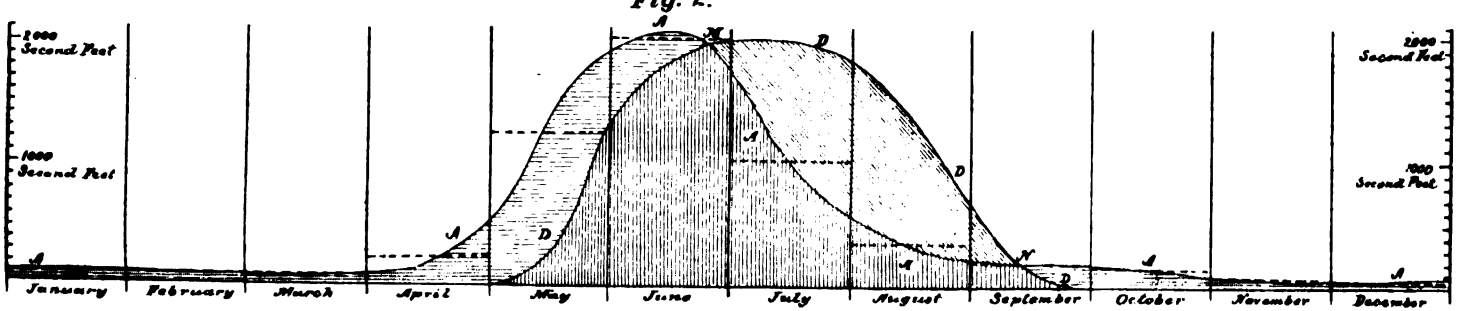


Fig. 2.



ıould be released upon requisition of the proper State officer (ordinarily ıe State engineer) in such quantities as may be required. The waters › released should be subject to the same local laws and regulations as ertain to the streams in their natural condition.

In this relation of nation and State there is no room for any clash of uthority, and there need be none. The reservoir would always be under control which would insure its efficient maintenance and the widest ossible range of benefits, and at the same time it would not interfere ı the least with local use. The only office of the Government in this ork would be that of rendering available certain natural resources hich now go to waste. Its province would end here, and the use and istribution of the resources so conserved would be governed wholly y local regulations.

In the acquisition of some sites more or less difficulty will be experinced in getting a full title. The most troublesome matter will be that f the condemnation of rights in futuro, or undeveloped rights—where arties have filed claims to sites, but have done nothing to develop them. ı such cases there ought to be no damages paid except those which epresent actual realized values, either acquired titles to lands, improveıents thereon, or other tangible forms of property.

XVIII.—MAGNITUDE AND COST OF WORK.

In case the Government should ever take up the work of constructıg reservoirs in the arid region, it will be a matter of great importance › understand as far as possible beforehand the probable magnitude of ıe work and its ultimate cost. Of course neither of these matters can e predetermined with very great accuracy, but still an estimate can e made which will give a fair basis for consideration of the subject. ıs already stated, in order to utilize fully the natural flow of the treams in the West, a certain percentage of that flow will have to be tored in reservoirs. This percentage will of course vary in different ›calities. The maximum flow of some streams comes much earlier han that of others, and is therefore less available to meet the maxiıum demand for irrigation. Again, the character of crops is an nportant element in the use of water. Some crops require water arly and others late in the season, and the combination of all, as cul.vated in a particular section, is necessary in order to determine the emand throughout the season. No absolute percentage, but only a eneral average, can therefore be fixed upon.

By way of general illustration, let us take the case of the Cache à la 'oudre River in Colorado. Its annual flow in cubic feet per second er month is shown on the curve A A A in the accompanying plate. 'he area within the curve may be taken as representing the entire flow ›r the year. According to Professor Carpenter, of the State Agriculıral College of Colorado, irrigation begins generally in May, reaches ıs maximum in June, which it nearly maintains through July, falls way rapidly in August, and generally ends in September. I have herefore assumed these limits in this illustration, and have repreənted by the curves B B B, C C C, and D D D the assumed demand uring the irrigation season. It will be understood that these curves re not intended to represent absolutely actual conditions, for the ariations in crops and seasons make this impossible. They are simply pproximations for the purpose of illustration.

Consider the curve B B B, fig. 1. It is clear that this amount of irrigaon could not be carried on from an unaided stream, for between Y, bout July 12, and Z, September 1, the demand exceeds the supply and

the irrigation curve lies above the curve of flow during that period. Clearly, the limit of economical irrigation from the natural stream will be when the two curves are tangent to each other, as at X, and this limit is shown by the curve C C C, fig. 1. The area within this curve is 32.7 per cent of the area within the curve of flow, or, in other words, 32.7 per cent of the flow of the stream can be economically used without the aid of reservoirs.

But this does not mean that the remaining 67.3 per cent of the stream must be stored in order that the whole may be utilized. Suppose, for example, that the deficiency represented by the space Y B Z X Y were made up by storage. Then an amount of water could be used that would be represented by the curve B B B. The total area of this curve is 47.8 per cent of that of the curve of flow, of which 5.1 per cent is stored water and 42.7 per cent is from the stream direct. But only 32.7 per cent, we found, could be taken from the stream direct in its natural condition. The storage of 5.1 per cent of its flow has, therefore, added 10 per cent to the amount which may be taken from the stream direct.

The limit of storage which will be necessary to utilize the whole stream will, therefore, be represented by the space M D D N A A M, fig. 2, when this space is just equal the space within the curve of flow and outside the curve of irrigation. This storage space is indicated either by the oblique or horizontal shading, which are equal in area to each other, and is a trifle less than one-half of the space denoted by the vertical shading, which represents the percentage of flow taken from the stream direct. The exact percentages, as derived from this illustration, are 32.5 per cent of stored water and 67.5 per cent taken out direct.*

It will thus be seen that for every cubic foot stored, over 2 cubic feet are made directly available. In addition to this, a certain amount is made indirectly available. The records of seepage in the Cache à la Poudre Valley show that about 30 per cent of the water of irrigation comes back into the stream and can be used again. This is rather a large percentage, but if it be taken at 25 per cent, then every foot of water stored makes available 2.5 feet.

As above stated, no figure of universal application is possible. Evidently the percentage to be stored will diminish as the crests of the curves of supply and demand approach each other in time, and will increase as they diverge. Still, about one-third of the total flow may be taken as a fair average the country over.

But even this percentage can be accepted only when the conditions are such that the entire flow of a stream can be gotten out upon the land. Now, it is well known that some streams are so located in deep and inaccessible canyons that it will be forever impossible to command their entire flow. Others lie partly in subhumid countries and their full flow will not be required. Add to this that private enterprise has already stored some water and will store more, and it will be seen that the actual percentage, which remains to be stored, will be much less than one-third. I have placed it at one-fourth of the entire flow.

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* See Appendix F, letters from Prof. Elwood Mead and F. J. Mills, State engineers of Wyoming and Idaho, respectively, which indicate 40 and 50 per cent as the probable proportion of stream flow to be stored. These gentlemen have made careful studies of stream flow in the West, and their opinions are entitled to great weight. Still, I am inclined to think that they may not have given sufficient weight to the point brought out in the above illustration, viz, that every foot of water *stored* enables a certain additional amount, perhaps another foot, *to be taken from the stream direct*. At any rate, it seems almost certain that, taking the arid region as a whole, and deducting for causes mentioned in the body of the report, the total amount necessary to be stored, computed upon the entire area, will not be more than one-fourth of the run-off.

The mean annual run-off from the entire arid West, omitting the Pacific Coast streams, does not exceed 2 inches. For the Missouri River watershed above Kansas City, about 490,000 square miles, it is 1.98 as a mean of 12 years. The few measurements that have been made upon other streams indicate for the Rio Grande above El Paso (watershed 30,000 square miles) 0.72 inch, and for the Colorado River at Yuma (watershed 225,000 square miles) 0.9 inch. The flow of the Snake River at its outlet (watershed 103,800 square miles) probably averages something over 2 inches. The Bear River in Wyoming and Utah (watershed 6,000 square miles) averages 4.6 inches at Colliston, Utah, and the Humboldt River at Golconda, Nev. (watershed 10,780 square miles), 0.44 inch. A mean of 2 inches, as above assumed for the entire arid region, would, therefore, seem to be an outside figure.

The area of the arid lands has been estimated at about 1,300,000 square miles. But this covers a greater extent of territory than can reasonably be included in the present estimate. Omitting the Pacific Coast watershed and the subhumid tracts east and west of the strictly arid zone, it is not likely that over 1,000,000 square miles can properly be considered as the total area over which the storage of water must be systematically developed. One-fourth of a mean run-off of 2 inches (one-half of an inch, equal to one twenty-fourth of a foot) over 1,000,000 square miles gives a total of 1,161,600,000,000 cubic feet.

But of course only a very small proportion of this water is in any present need of storage. It will all be needed only when the agricultural development of the country approaches its limit, and that is certainly a matter of not less than a century—probably much more. To give definite figures to the calculation, however, assume the entire completion of a comprehensive storage system for the streams of the arid region to be the work of only a hundred years. The average annual amount of reservoir construction to be done to realize this final total would be represented by a storage of 11,600,000,000 cubic feet, or 266,300 acre-feet.

The average cost of storing an acre-foot of water, on the basis of the work estimated for in this report, is $2.88 per acre-foot, computed upon the full capacity of the sites, or $5.37, computed upon the supply immediately available. (See Section IX on conclusions and recommendations as to the sites examined.) While this cost will undoubtedly increase, in the item of right of way, with the settlement of the country, as well as with the progressive utilization of the best sites, it will also diminish in the item of the execution of the work, which will always grow less in proportion as the country becomes more thickly settled. Whether, on the whole, the unit cost will increase or diminish can not be foretold. It will be better, in any event, to take the larger of the above figures as the unit basis in our estimate. The cost of storing 266,300 acre-feet of water at $5.37 per acre-foot amounts to $1,430,031, which may be taken as a fair estimate of the annual cost of developing a comprehensive storage system in the West in a period of one hundred years. The average annual cost of maintenance, as already stated, may be taken at about 1 per cent of the original cost of construction.

The present annual value of an acre-foot of water varies from 50 cents to $3, depending upon localities. This will of course go on increasing with time, for as the land becomes systematically cultivated and the water supply approaches its limit, greater economy is practiced and water goes much further than when there is a surplus for all users. As previously stated, a considerable percentage of the water used in irrigation comes back in seepage and is subject to a second or third use. Then, as was shown in another place, every acre-foot of water

stored makes available a much larger amount, sometimes twice as much. All these considerations, coupled with the growth of the country and the consequent rise in the remunerative value of natural resources, make it a conservative estimate to place the future average annual value of *stored* water for irrigation alone throughout the arid West at not less than $2 per acre-foot. At that rate the original cost, with maintenance added, would be returned within an average period of less than three years.

Distributed among the States and Territories, seventeen in number, where irrigation is practiced, including those which lie partly within and partly without the arid belt, the above annual expenditure of $1,430,031 would be equal to $84,119 each.

Inasmuch as the examinations herein reported upon were authorized and directed by an act of Congress making appropriations for rivers and harbors of the United States, it will be of interest to inquire how far this additional work would probably augment the total expenditure for these objects, and how it would affect the distribution of this expenditure among the people. Although an important work like that of deepening the Passes of the Mississippi is as much a benefit to each of the States having a commercial outlet through that stream as it is to the one in which it happens to be situated, still the benefit which the expenditure in itself brings to the immediate locality, entirely apart from the ultimate value of the completed work, is a matter which has always received great consideration in drafting the river and harbor bill, and it seems to have become a settled policy not to confine these benefits to the few more important localities, but to distribute them generally throughout the country. How far this policy is exemplified in recent legislation may be seen from the following table, which gives the appropriations for 1897 and 1898, distributed among the States where the expenditures are to be made, as closely as such a distribution is possible:

Distribution, by States and Territories, of the appropriations for rivers and harbors contained in acts of Congress of June 3 and June 11, 1896, and June 4 and July 19, 1897, omitting all contract obligations, the sum for examinations and surveys ($200,000), and the regular annual payment of $100,000 for maintaining the channel in the South Pass of the Mississippi.

States and Territories.	Amount.	States and Territories.	Amount.
Alabama	$545,500	Montana	$94,000
Alaska	5,000	Nevada	0
Arkansas	876,389	Nebraska	204,000
Arizona	0	New Hampshire	25,000
California	4,156,750	New Jersey	762,660
Colorado	0	New Mexico	0
Connecticut	267,000	New York	3,125,008
Delaware	849,494	North Carolina	256,000
District of Columbia	100,000	North Dakota	61,560
Florida	812,000	Ohio	836,000
Georgia	783,500	Oregon	876,325
Hawaiian Islands	10,000	Pennsylvania	2,102,000
Idaho	30,000	Rhode Island	936,000
Illinois	2,330,499	South Carolina	449,500
Indiana	331,000	South Dakota	54,000
Indian Territory	60,000	Tennessee	1,265,000
Iowa	449,334	Texas	2,042,000
Kansas	150,000	Utah	0
Kentucky	1,284,889	Vermont	15,000
Louisiana	1,520,388	Virginia	338,000
Maine	951,500	Washington	1,284,798
Maryland	508,800	West Virginia	710,000
Massachusetts	842,500	Wisconsin	1,012,635
Michigan	2,496,075	Wyoming	0
Minnesota	751,083		
Mississippi	1,272,289	Total	39,492,094
Missouri	1,780,889		

This total, less the amounts to be expended in Alaska, Hawaii, and the District of Columbia, divided by 42, the number of States and Territories in which the expenditures have been or are to be made, gives an average of $937,549 for the two years covered by the appropriations, or $468,774 for each year. Should Government control and regulation of navigable streams be extended to include the storage of any portion of their surplus waters in the arid regions, such an extension will apparently cause an increase of only about one-seventh in the present expenditure, while it will tend to secure a more equitable distribution of that expenditure among all sections of the country.

A feature of great importance pertaining to the cost of public works of the character of this proposed reservoir construction merits particular attention in comparison with that of other public works of the Government. When a reservoir is once constructed, there will be no further occasion for expense except for maintenance, which, as before stated, will not exceed 1 per cent annually upon the original cost. With the present river and harbor works, and even with public buildings, this is not so. The growing requirements of business and the perishable nature of many kinds of work keep up an increasing demand for further appropriations. But a reservoir once built as it should be is a thing done. Its capacity, if sufficient at first, will be sufficient forever. No increase of business will make the run off from its watershed any greater or render it less adequate for the purpose for which it was designed. Its immunity from deterioration or decay will make it unnecessary ever to replace it. In fact, an expenditure of this sort possesses the almost unique merit of being one that the Government may know is final when once made.

XIX.—SUMMARY.

The substance of the foregoing report may be briefly summarized as follows:

(1) All varieties of reservoir sites or of dam construction likely to be encountered in the arid section of the United States are exemplified in the sites considered in this report.

(2) Five reservoir systems have been examined under the provisions of the act of June 3, 1896—three in Wyoming and two in Colorado. These are—

(*a*) The Laramie site, near the town of Laramie, Wyo., for storing the waters of the Laramie and Little Laramie rivers, and possibly of the North Platte and other streams. Available supply from the two Laramies, 46,000 acre-feet; estimated cost for storing waters from the two Laramies, $416,254.14; cost per acre-foot, $9.05. Water now needed. Cost of bringing North Platte into basin, possibly as much as $1,000,000. Supply would add 328,000 acre-feet to storage of reservoir and would reduce cost per acre-foot to $3.43.

(*b*) Sweetwater site. Capacity, 326,965 acre-feet; cost, $276,484.80; cost per acre-foot, $0.85. Storage not yet urgently needed. Probable annual storage when stream is fully utilized will be 100,000 acre-feet. Cost per acre-foot on this basis, $2.76.

(*c*) Piney Creek system, consisting of three sites: Cloud Peak site, near source of stream; capacity, 6,800 acre-feet; cost, $31,048.75; cost per acre-foot, $4.56. Piney site; capacity, 11,020 acre-feet; cost, $70,226.25; cost per acre-foot, $6.37. Lake De Smet site; capacity, 67,628 acre-feet; cost, $113,360; cost per acre-foot, $1.67.

In case the National Government should undertake the work of reservoir construction in the West, the Piney system would be rec-

ommended for first consideration in Wyoming. The water is now urgently needed. Construction should proceed in the following order: Piney site first, Cloud Peak site next, and lastly Lake De Smet. The work should cover three years. The first appropriation should be $100,000.

(*d*) The South Platte site, in Colorado. Capacity, 41,320 acre-feet; cost, $540,000; cost per acre-foot, $13.07. This site should receive first consideration of the two examined in Colorado. The water is now urgently needed. Construction should take three years. The first appropriation should be $200,000.

(*e*) The Loveland site, in Colorado, for storing waters from the Big Thompson and Cache la Poudre rivers. Capacity, 45,741 acre-feet; cost, $262,106.34; cost per acre-foot, $5.73. Storage now needed. Complication with existing rights renders project for Government construction one of doubtful advisability.

(3) The function of reservoirs will always be primarily the promotion of industrial ends; secondarily only, a possible amelioration of flood conditions in the rivers.

(4) While it is perhaps physically practicable to build reservoirs of sufficient aggregate capacity on the watershed of any stream, even so large a stream as the Mississippi, as to exercise some influence in diminishing the height of floods, the great cost of such works, as compared with the results to be expected from them, will always prohibit their construction, unless it is called for by other and more direct causes.

(5) A general system of reservoirs in the arid regions sufficient to contain the flow of the streams over what it is possible to draw from them directly in irrigation would, it is believed, cause some reduction in the flood height of the Missouri River during the June rise. The amount of this reduction would, of course, depend upon the distance of the section of river considered from the points of storage, and would diminish rapidly with an increase of this distance.

(6) Reservoir construction in the arid regions of the West is an indispensable condition to the highest development of that section. It can properly be carried out only through public agencies. Private enterprise can never accomplish the work successfully. As between State and nation, it falls more properly under the domain of the latter.

(7) Reservoir construction by the General Government need not in any way involve Government control of irrigation works. These should be left in the hands of the States and of private individuals under State laws.

(8) The Government should acquire full title and jurisdiction to any site which it might improve, and full right to the water necessary to fill the reservoir. It should build, own, maintain, and operate the works itself. It should hold the stored waters absolutely free to public use under local regulations, subject only to the right to close the reservoir whenever flood protection or other emergency should require.

(9) The total extent of a reservoir system in the arid regions which shall render available the entire flow of the streams will not exceed 1,161,600,000,000 cubic feet. If the construction of such a system were to consume a century in time, it would represent an annual storage of about 11,600,000,000 cubic feet, or 266,300 acre-feet. At $5.37 per acre-foot this would cost $1,430,031 per annum. This amount, distributed among the seventeen States and Territories of the arid section, gives an average annual expenditure in each of $84,119. The annual value of the stored water would return the original cost and maintenance in an average period of three years.

APPENDIX A.

REPORT OF MR. F. B. MALTBY, ASSISTANT ENGINEER.

CAPTAIN: I have the honor to submit the following report upon the examinations of reservoir sites in Colorado and Wyoming made by me during the past summer:

In accordance with your instructions, I left St. Louis on May 4, 1897, arriving in Denver on the 6th. I immediately organized a small survey party and proceeded to a point selected by you for examination on the South Platte River.

The work required at this point was completed May 21, and I proceeded to Laramie, Wyo., where another examination had been ordered by you. Work was continued there until June 11, when I proceeded to a point on the Sweetwater River in Wyoming and examined a site already selected by you. Work was completed there on June 19, and I returned to Laramie. On account of the limited time at my command, I left Mr. S. F. Crecelius, assistant engineer, in charge of a small survey party at Laramie to complete some details of survey work.

I proceeded to the North Platte River at Pinkhampton, Colo., Cheyenne, Wyo., Greeley, Fort Collins, Loveland, and Denver, Colo., making such examinations and procuring such information as was possible and that would be valuable in making a report on the value, feasibility, and cost of constructing reservoirs at the proposed sites. I arrived in St. Louis and reported for other duty on July 3.

Mr. Crecelius completed the work at Laramie on June 30 and proceeded to Loveland, Colo., where an examination was made of a proposed reservoir site. He completed this work on July 18 and returned to St. Louis, and has since been engaged in completing the maps of the sites examined.

The examinations made at each site consisted of making such surveys as were necessary to determine the outline, area, and capacity of the proposed reservoirs; the determination of the land subdivisions that would be submerged; the determination, as far as possible, of the amount of water available for storage; the distance to the point of application of the stored water, its value, and such miscellaneous information as to local prices as would be of value in making a preliminary estimate of the probable cost.

All surveys were made by the stadia method by Mr. S. F. Crecelius, assistant engineer, to whom I am indebted for much assistance in obtaining desired information.

Elevations above the sea depend in each instance on railroad levels. The surveys depend for direction or azimuth on observations on Polaris at South Platte; on azimuth furnished by the United States Geological Survey at Laramie, and on compass determinations at the Sweetwater and Loveland sites.

Following is a detailed description of each site examined:

SOUTH PLATTE, COLORADO.

It is proposed to form a reservoir by damming the South Branch of the South Platte River about 50 miles above Denver and 20 miles by river above the junction of the North and South branches. The site of the dam is about one-fourth of a mile below Lost or Goose Creek, and is in the southwest quarter of section 6, township 10 south, range 70 West. The nearest railroad station is South Platte, on the Denver, Leadville and Gunnison Railroad. The distance by existing roads is about 28 miles. It is, however, feasible, by the expenditure of $3,000 to $4,000, to construct a good road to the dam site connecting with existing roads, making the distance not over 20 miles, 9 miles of this distance being along an abandoned railroad grade.

The proposed dam would be built in a narrow canyon, only about 35 feet in width at the surface of the river. The solid rock sides rise nearly vertically to a height of from 90 to 100 feet. Above this point they slope back to such an angle that at about 200 feet above the water they are about 500 feet apart. At an elevation of approximately 200 feet above the river there is across the adjacent ridge a natural depression which would form a spillway over solid rock. In order to take advantage of this spillway, the dam should be from 210 to 215 feet in height. The rock at the site is a red granite.

A portion of the rock on the surface, immediately adjacent to the dam, has disintegrated and would require removal. Samples taken from tunnels and shafts in the vicinity show a compact and solid rock.

It is entirely practicable to quarry all the rock required for the construction of a dam immediately adjoining the site, and by the use of cableways of moderate length stone could be carried from the quarry face to its position in the wall.

If concrete is to be used, finely crushed granite will furnish an excellent substitute for sand; or, if sand is desired, an abundance of clean, sharp material can be secured from the bars in the river, from one-half to 1 mile distant.

There is an abundance of good pine timber covering the reservoir site, sufficient for all purposes of construction, and within 2 miles from the site of the dam.

The reservoir which will be formed lies in Jefferson and Douglas counties, the river being the dividing line between them. Nearly its entire area would be in township 10 south, range 71 west. This township is in what is known as the "Forest Reserve," and has not been subdivided.

The length of the reservoir would be about 5¼ miles; the extreme width about one-third mile. The elevation of the proposed water surface is, approximately, 6,840 feet above the sea, and at this elevation would have an area of approximately 775 acres, and an approximate capacity of 3,000,000,000 cubic feet, or 68,870 acre-feet.

Assuming a loss from evaporation and seepage from the reservoir itself and from the stream after being discharged from the reservoir and before being drawn into irrigating canals as being 25 per cent, leaves a net available capacity for irrigation of 51,653 acre-feet, or about 50,000 acres, as the area that could be irrigated from the reservoir.

Of this, Mr. H. A. Sumner, formerly State engineer of Colorado, estimates that 75 per cent would be additional acreage above the amount now irrigated from the South Platte River.

The ordinary flow of the river during the irrigating season, extending from May 20 to September 20, is all appropriated. It is assumed, however, that from October 1 to May 1 all the water passing Deansbury, just below the junction of the North and South branches of the South Platte River, in excess of 100 second-feet, and from May 1 to October 1 in excess of 250 second-feet, could be stored without conflicting with existing rights. An inspection of the discharge curve at this point, and assuming the discharge at the proposed dam as being in proportion to the discharge at Deansbury as its drainage area is to the drainage area above Deansbury, shows that in ordinary years there would be sufficient water to fill the reservoir.

The site has been filed on as a "reservoir site" under the laws of Colorado by the South Platte Canal and Reservoir Company in August, 1897, and their claim has been approved by the Secretary of the Interior. The company is practically identical with the Denver Union Water Company.

An inspection of the United States Land Department records at Denver on May 22, 1897, shows that this is the only valid claim against the land.

Numerous placer and lode claims have been filed, but none up to the above date had been approved or patented.

LOVELAND, COLO.

The site of the proposed reservoir is a natural depression known as Boyds Lake, in the high ground between the valleys of the Cache a la Poudre River and Big Thompson Creek. It is proposed to divert and store the waters from these two streams during the time of floods and at such times as there may be a surplus of water over that actually used for irrigation, and to release the water so stored at such times as there is a deficiency in the streams.

The depression which it is proposed to utilize is a natural basin entirely surrounded by high ground, and will require no dam. It is about 3 miles northeast of Loveland, Colo., and 4 to 5 miles from the foothills. It lies in secs. 29, 30, 31, and 32, T. 6 N., R. 68 W., and secs. 5, 6, 7, and 8, T. 5 N., R. 68 W.

The area of the reservoir would be approximately 1,920 acres, and its capacity 1,992,468,000 cubic feet, or 45,740 acre-feet.

The surface of the present lake is constantly being raised by seepage and waste from adjacent irrigated land, and it is estimated that this seepage would, with full reservoir, at least make good the loss by evaporation, and that the total amount stored would be available for irrigation.

The discharge of the Cache à la Poudre River and Big Thompson Creek is shown in the report of the State engineer of Colorado for 1894.

An inspection of these diagrams, and knowing the amount of water appropriated, and confirmed by the courts, would seem to indicate that there would be no water available to fill the reservoir.

The total valid appropriation on the Cache à la Poudre is approximately 4,500 second-feet, which is more than the total discharge of the stream, except during possibly one month in the year.

It is estimated by Prof. L. G. Carpenter, of the Colorado State Agricultural College, that the actual capacity of the ditches in use is not over two-thirds the above amount. It is also estimated by the same authority that by careful practice in diverting into the reservoir all the water not actually used or required, the reservoir would be filled on an average of five out of six years.

Some of the advantages claimed for this site are, first, that it is not in the valley or bed of a running stream; that it requires no expensive dam, and is not subject to the destructive effects of unusual floods, and that the confidence of the people who live below it, in its security, is much greater than possible under any large or high dam. It is near the foothills, and it is urged that there is an especial advantage in this fact, as there is less loss from evaporation and seepage from the streams before

being diverted. It also permits the use of the stored water well up in the valleys, and thus secures to the land lower down the stream the benefits of the seepage or return flow from lands to which the water is first applied. The importance of this feature is shown in Bulletin No. 33, State Agricultural College of Colorado, on "Seepage or return waters from irrigation," by Prof. L. G. Carpenter.

The storage and preservation of all the surplus water of these two streams seem particularly desirable, as all the flow during the irrigating season is used, and there is urgent need of all the water that can be added to the normal flow during the season.

The water from these streams irrigates the country included in and surrounding the well-known "Greeley Colony," and it is probable that irrigation practice in this locality has reached a higher degree of development than in any other part of the State. The water would be diverted and used almost immediately below the discharge tunnels from the reservoir. It is estimated by Professor Carpenter that in this locality an acre-foot of water has a value to the community of from $7 to $10 per year.

It is proposed to divert the water from the Big Thompson Creek through the Loveland and Greeley Canal, which has a capacity of 500 feet per second. It should be enlarged to a capacity of 800 second-feet in order to use all the flood waters.

From the Cache à la Poudre River the Mercer Canal or the Laramie County No. 2 can be enlarged, and about 6 miles of new canal built, connecting them with the reservoir. It would, however, probably be more economical to build an entirely new canal.

This site has also been filed on by a company known as the "Boyd's Lake Reservoir Company." This company, however, has signified its willingness to relinquish to the Government all its claims for the amount actually expended for surveys, incorporation, etc., amounting to $1,400.

LARAMIE SITE, WYOMING.

It is proposed to divert the surplus water of the Big and Little Laramie rivers and store them in a natural depression known as the "Big Hollow," the northeast end of which is about 5 miles west of Laramie City. This hollow or depression lies between the Big and Little Laramie rivers and in what is known as the Laramie Plains. It is in townships 15 and 16 north, and ranges 74 and 75 west. The southwestern end is but a short distance from the foot of Sheep Mountain.

It is about 10 miles long and 2 miles wide, and has a maximum depth of 175 feet. The elevation of the river at the northeast end and at its lowest point is 7,260 feet above the sea, or about 110 feet above the railroad at Laramie City. The area at this elevation is about 13,650 acres, and its capacity approximately 40,817,405,000 cubic feet.

The surrounding land slopes away from the rim of the basin in all directions, and it thus has no drainage area except that within its own rim.

The following report on the geological formation of this basin has been prepared by Wilbur C. Knight, professor of geology and mining, of the University of Wyoming at Laramie:

"This basin is located in cretaceous rocks, and has been eroded from rock in place. With the exception of the northern rim, the formation is exposed at intervals surrounding the site. Along the eastern border the rocks have been eroded so as to leave a long, narrow elevation of rock and loess, forming what would be the shore line of the reservoir. Near the center of the eastern border the Niobrara white beds, which resemble the Kansas chalk, are exposed, and form the rim of the depression to the north end. To the south of this point bands higher up in the group form the border. This group underlies all the basin and extends westward to the bluff forming the western border. The western border is chiefly Fort Pierre group. The cretaceous rocks of the Laramie plains generally dip slightly to the west and have nearly a uniform strike north and south. There are, however, occasional disturbances in which the rocks vary from this rule. There are evidences of some local movements in the vicinity of this site, but I am not able to characterize them. The rocks composing the geological groups mentioned are chiefly sandstone, shales, clays, and marls. Soil formed by the decomposition of these bands is usually argillaceous, and would make excellent material for the bottom and sides of a reservoir site, because it prevents great losses by leakage.

"I am unable to offer any absolute solution as to the formation of this great basin. It has been done by erosion, but I am not able to say, without further study, whether it was glacial or aqueous. It is also very probable that it might have been a combination of these forces, and materially aided by wind erosion. In case this depression was made by either ice or water, it had to have an outlet, which would naturally have been at some point near the north end of the basin.

"At present there is no sign of any outlet, and the entire surface is covered with

loess. If such an outlet ever existed, which I consider highly probable, it was subsequently filled with either loess or gravel. The existence of an old water course of this nature would seriously affect a storage reservoir of this kind, unless it was properly cemented, for an outlet of this nature would be porous enough to carry out a good-sized stream. In no other place about the basin is there any evidence in hand that would warrant one in saying that there would be danger of a serious leak."

It is proposed to draw the water from the reservoir through a tunnel at the northeast end, as shown on the map, and discharging into the Big Laramie River a short distance below Laramie City. Such borings as could be made with crude apparatus procured at Laramie indicate that the material encountered in driving this tunnel is a compact clay, and little if any rock would be encountered.

The map also shows the approximate location of the canals from the Big and Little Laramie rivers. That from the Big Laramie would be diverted from the stream 4 or 5 miles below the mouth of the canyon, and that from the Little Laramie only about a mile below where it emerges from the hills.

Both canals would command all the land lying between them and the rivers, and would be available as irrigating canals during the season of irrigation. Their use for this purpose would permit of the abandonment of several existing small ditches leading from the river and a consequent saving in the loss from evaporation and seepage.

The actual amount of water available for storage from these streams can only be approximately estimated, as continuous-discharge measurements are not available.

Assuming a discharge of 100 cubic feet per second of the Big Laramie at Wood's Landing during the winter months, as estimated by Mr. Elwood Mead, State engineer of Wyoming, and taking the discharge of the river from April to October, from the report of the State engineer of Wyoming in 1894, and assuming that during the time from October 1 to June 1 all the water could be stored, and between June 1 and October 1 that all in excess of 300 cubic feet per second could be stored, would give an average daily discharge available for the year of 200 cubic feet per second, or a total per annum of 6,307,200,000 cubic feet.

Assuming the flow of the Little Laramie to be one-half as much, would give a total yearly supply of 9,460,800,000 cubic feet, or only about one-fourth the capacity of the reservoir, and from this amount the loss from evaporation must be subtracted.

A very hurried barometric reconnoissance was made between Wood's Landing on the Big Laramie and the north end of North Park on the North Platte River, to determine if it was possible to divert the water of the North Platte into the Big Laramie. It was found that the North Platte is approximately 400 feet higher than the Big Laramie at the point mentioned.

Much more extended investigation is necessary to determine the practicability of the scheme, but it is entirely possible that a location for a tunnel may be found between the two streams that would not be over 5 to 10 miles in length.

SWEETWATER RIVER RESERVOIR SITE.

At this site it is proposed to form a reservoir by damming the Sweetwater River at a point, known as the Devil's Gate, about 65 miles nearly due north of the town of Rawlins, Wyo.

The problem presented at this point is a very simple one, and for that reason possesses more than ordinary merit.

The Sweetwater River flows for a number of miles along the south base of a narrow granite ridge extending nearly east and west. At the point selected for the dam it flows through this ridge in a gorge only about 35 feet wide at the water surface, and about 300 feet wide on top, and 380 feet deep.

It is proposed to build a masonry dam in this gorge about 100 feet high. This would form a reservoir about 13 miles long and a mile to a mile and a half in width. It would have an area of 10,800 acres and a capacity of approximately 14,150,000,000 cubic feet. The walls of the gorge are a gray granite, very hard and compact. There is an abundance of rock that can be quarried and placed in position in the wall direct, and would require handling but once.

An abundance of sand can be had from the banks of the stream adjoining the site.

The elevation of the surface of the reservoir is approximately 6,000 feet above the sea.

At present there is but very little irrigating done from the Sweetwater River in this vicinity, and there is not the urgent need of stored water as at some other points, but for future development the site offers possibilities for the cheap and simple storage of a large quantity of water which can hardly be surpassed.

A continuous discharge of the river has not been taken, but it is probable that the flow is ample to fill the reservoir each year.

A number of photographs were taken of the sites examined, and are submitted herewith.

I am under many obligations for information furnished me by Messrs. H. A. Sumner and L. R. Hope, civil engineers, of Denver; Prof. L. G. Carpenter, of Fort Collins, Colo.; Mr. Elwood Mead, State engineer of Wyoming, and Mr. C. E. Whiting, city engineer of Laramie, Wyo.

Very respectfully submitted.

F. B. MALTBY, *Assistant Engineer.*

Capt. H. M. CHITTENDEN,
Corps of Engineers, U. S. A.

APPENDIX B.

REPORT OF MR. FRED BOND, ASSISTANT ENGINEER.

BUFFALO, WYO., *October 23, 1897.*

CAPTAIN: I have the honor to submit herewith a report upon an examination made by me of the watershed of Piney Creek, Wyoming, together with such plans for storage reservoirs as will fully utilize the flow of this stream.

THE WATERSHED.

Piney Creek is one of the largest streams used for irrigation in north central Wyoming. Rising, as it does, among the impassable cliffs and canyons radiating from the summit of the Big Horn Mountains, its waters are fed by immense accumulations of snow and ice which fill every crevice, gorge, and canyon. The total volume of water here conserved may not be accurately known, for the heat of the sun never reaches far into many of these ice-filled gorges, but it is certainly not exceeded anywhere in the Rocky Mountain region. So large and deep are many of these deposits of snow and ice that it would take a keen and practiced eye to discern the changes taking place from week to week, but the foaming flood, large in volume and larger in commercial importance, which throughout the summer leaves the mountains 18 miles below demonstrates a continually decreasing reserve.

Generally speaking, the summit of the Big Horn range consists of seven or eight peaks extending nearly north and south for 20 miles and all above 12,500 feet altitude. They form a conspicuous landmark for this whole region and are crowned near the northern end by the snowy dome of Cloud Peak, rising to an altitude of 13,200 feet. On the east slope and near the summit of this highest peak Piney Creek takes its rise. The very headwaters are found in Lake Bryant, situated at the base of the wall, which for 1,000 vertical feet forms the eastern and northeastern side of the peak. The walls of this lake, which are 300 feet in height at the lowest point, are covered by vast banks of snow, and its surface remains frozen throughout the year. It is the first of a series of twelve lakes, eight of which are above Cloud Peak Reservoir, forming a system of natural reservoirs unsurpassed as a factor in conserving winter moisture for summer use. The melting snows around Lake Bryant escape through and under the immense gneiss bowlders and loose trap rocks which constitute the lower wall, and, roaring far beneath one's feet, enter the second lake of series. From this lake the stream passes again under the rocks to the third basin, from which, through constant and ever-increasing additions to its volume, it becomes an open torrent, with wide and clear cut through ragged walls.

From the source to Lake Mead, the eighth of the series and the first above Cloud Peak reservoir, Piney Creek flows through a deep canyon, with precipitous walls, banked up on both sides with drifts of snow as obtain everywhere in this region. Gorges filled in the same way, each of which is the head and source of a distinct stream, enter the main canyon at numerous points and from every direction throughout its source of 5 miles from the head to Lake Mead, and in this way in the comparatively small scope of country of 25 square miles this large and valuable irrigation stream is formed.

About one-half mile north of the head of this main fork of Piney Creek just described the middle fork finds its source. A chain of five lakes, all visible from a neighboring summit, lie along the bottom of the canyon, the east walls of which at this point rise vertically for 2,000 feet. The banks of snow at the head of these lakes constitute the ultimate source of the water supply here also, and the characteristics of the main stream are repeated here. The streams unite 8 miles from the source of the middle fork and 12 miles below the head of the main stream. About 4 miles below the junction of these two streams, north fork of Piney Creek adds its quota to their combined waters. This stream, although a considerable body, is smaller than either of the other two, and does not rise so far back in the snowy range. Its flood waters are consequently the first to pass down the mountain, and

are largely exhausted before the main stream begins its spring rise. Very little, if any, of the waters of north fork are utilized for irrigation, and nothing short of artificial impounding will save them for the farmer.

The course of each of the large divisions of the creek for the first 4 miles from its head is above timber line, and the inclosing walls between which it runs are bare of vegetation, except for scattering patches of mountain grasses and a few wild flowers. At this distance down the slope both streams enter dense forests of spruce, fir, and balsam, which a few miles farther down give place to the forests of pine which obtain from this point to the foot of the range. Excepting two or three small open parks and the gorges and canyons above timber line, the whole watershed of Piney Creek lies among the pine and spruce covered slopes of the east side of the Big Horn range. The timber hereon is not all large nor old, and in places shows the effect of previous forest fires; but a healthy and vigorous growth now covers even those parts of the region latest visited in this way, and the spruce and fir farther back toward timber line show no evidence of ever having been attacked.

THE AVAILABLE WATER.

The flow of water in Piney Creek has not been regularly ganged from year to year, and for this reason no accurate continuous record can be given. A number of individual gaugings, however—some crude, some accurate—have been made. An accurate one by the State engineer of the State of Wyoming in June, 1893, gave a flow of 1,500 cubic feet per second of time. The flow of that year was unusually large, and my own view, based on a number of rough gaugings back in the mountains and continuous observations during three consecutive years, is that 500 cubic feet per second of time is a fair estimate of its average flow in June and the first half of July of each year. Its discharge during the earlier spring months is smaller than this, though probably is not less than 300 cubic feet. From the middle of July until the middle of September it again largely decreases, and is not sufficient to supply the demands of those appropriators having canals already constructed and land under cultivation. During the fall and winter months the total flow of the stream is about 150 cubic feet per second.

UTILIZATION OF THE STREAM.

From the 1st of October to the middle of the following May practically all the flow of Piney Creek goes to waste, and during the spring floods of June and the first half of July only a small portion of the water is utilized. From the 1st of August to the middle of September its flow does not nearly supply the demand made upon it, as heretofore stated, so that in summing up it is seen that all the flow from the Piney watershed for eight months in the year is entirely lost, and that during the remaining four months a large part is wasted owing to the fact that the first half of that period is the flood season.

The question of the conservation of these waters becomes, therefore, of vital interest to the State of Wyoming, and in a general way to the public at large, since one of the prolific sources of mischief along the Missouri River bottoms will have been dammed and retained where the water is needed. Thirty thousand acres of land are now partially irrigated with that part of the midsummer flow which is utilized, and 10,000 completely so; but with this volume reclamation stops, since all is used that can be under present conditions. For the conservation of the entire flow of this stream, which will add 30,000 acres of reclaimed land to the material wealth of the nation, the reservoir system as planned and submitted herewith is believed to be ample. The need of the waters for the purposes of irrigation is a crying need, but nothing could be plainer than that the benefits so conferred only surpass those received indirectly through the consequent diminution of the destructive floods of the large rivers farther down. The estimated expense of storing these flood waters is, compared to their value, very small, while the benefits are great and lasting.

CLOUD PEAK RESERVOIR.

As previously intimated in the report on the Piney watershed, the site selected for this reservoir is that now occupied by lake No. 9 of the series of twelve which form a part of the basin of Piney Creek. This lake is nearly 1¼ miles in length and a little less than one-half mile in width. Its location is about 1 mile below timber line, at an altitude of 10,000 feet, and it is surrounded by dense forests of spruce, fir, and balsam. The water is clear, cold, and of unknown depth, although near the lower end, where the lake narrows to the site for the dam, a few soundings gave an average depth of 52 feet. The plans for utilizing this site call for a dam 34 feet in height at

the highest point and contemplate a rise in the surface of the lake of 30 vertical feet. In addition to this, 10 feet of water below the present level is to be drawn off through the sluiceway constructed for drawing off the water impounded by the dam. It is thus proposed to draw off 40 feet of water from a surface having an average superficial area of 170 acres, making 6,800 acre-feet, or 300,000,000 cubic feet of water all told. Piney Creek enters one end of the lake and flows out at the other, and the drainage area tributary to the lake is coincident with that of the creek to this point, and is 30 square miles in extent. Its character has been heretofore described. Two plans for a dam are submitted, one of earth and loose rock and the other of loose rock with concrete core. Both are feasible, but the latter is the cheaper. The cost of the former is estimated at $24,839, and of the latter at $21,259, each complete and ready for use. The site for Cloud Peak Reservoir was originally located and right of way obtained from the United States by a company of Rock Creek, Wyo., farmers, associated together and known as the Rock Creek and Piney Reservoir and Ditch Company, and there is transmitted herewith a retransfer to the United States of all rights appertaining to said right of way accruing to the company above, conditioned on the construction of the work by the Government.

This reservoir is located in sections 9, 16, and 17, township 51 north, range 85 west, of the sixth principal meridian in Wyoming.

PINEY RESERVOIR.

The site for this reservoir is an open park about 1¼ miles in length and 1 mile in width. It is on the main fork of Piney Creek and is about 6 miles below Cloud Peak Reservoir. It is not a lake, but is a natural basin, through which Piney Creek flows from end to end, and is selected for reservoir purposes because of the comparatively small expense attached to impounding a large body of water here. It is surrounded by pine forests, where banks of snow are found still plentiful in the middle and last of June, and has a drainage area tributary to it of 65 square miles. The altitude of this site is 8,800 feet. The plans for utilizing this basin for reservoir purposes call for a dam 54 feet in height at the highest point and contemplate storing water to a depth of 50 feet. The superficial area covered by this reservoir when full is 368 acres, and the volume of the water impounded is 11,040 acre-feet, or 480,000,000 cubic feet. The construction is of earth, backed by loose rock, and the estimated cost is $56,277, complete. This reservoir was originally located by the Rock Creek and Piney Reservoir and Ditch Company, and right of way from the United States obtained as in the case of Cloud Peak Reservoir. A retransfer of all rights accruing to the company on account of said grant of right of way and under the same conditions is also transmitted herewith. Piney Reservoir is located in sections 23, 24, 25, and 26, township 52 north, range 85 west, of the sixth principal meridian in Wyoming.

LAKE DE SMET RESERVOIR.

The two reservoir sites heretofore described form what might properly be termed the winter storage basin for surplus Piney waters, since both of these reservoirs, being located directly upon the stream itself, may be utilized in impounding the winter flow, a supply that may not be conserved in any other way. To supplement these and catch the surplus flood waters is the proper function for Lake De Smet Reservoir. The site of this reservoir is a natural lake located in the rolling country just to the east of and about 6 miles from the foot of the Big Horn range. It is situated in a natural basin, is 3 miles in length by 1 in width, and will require no dam for impounding additional water. It is designed that the surface of this lake shall be raised 30 feet by the introduction of surplus and flood water from Piney Creek. For this purpose a canal 3½ miles in length will be required, and water can be run through it at any time of the year except during the four months of winter. This reservoir when full covers an area of 2,415 acres and will hold 67,628 acre-feet, or in round numbers 3,000,000,000 cubic feet of water. The outlets or drainage canals are located one at each end of the reservoir. The one at the north end discharges its waters back into Piney Creek, whence they may be utilized both in reclaiming new land and supplementing the shortage of appropriators on that stream. The other, at the south end, discharges its water onto the broad but hitherto uncultivated valley of Box Elder Creek, where for a distance of 12 miles it may be used almost entirely on virgin soil. The residue passes thence into the valley of Clear Creek, where for 35 miles the land lies waiting the plow of the pioneer. There is practically no limit to the extent of irrigable land that can be brought under the influence of a water supply in Lake De Smet, and the amount that will be so brought depends entirely upon the volume impounded there.

The improvements designed for this reservoir consist of a supply canal and the

two outlets or drainage canals, with their necessary gates and sluiceways. The supply canal has a fall of 4 feet to the mile, and at 7 feet depth of water has a carrying capacity of 725 cubic feet. The banks are sufficiently high to permit of one or two feet additional in depth being carried in safety as soon as the earth becomes settled. It is believed that this is amply large to fill all requirements. Each discharge canal is supplied with one 6-foot sluice gate, which will discharge 425 cubic feet per second—enough to satisfy all probable demands upon it.

There are no private claims connected with this reservoir as such, but there will be a few hundred acres of grazing land submerged in raising the water level. Their estimated value is included in the estimates of cost, which amount to a total of $90,688 complete.

Lake De Smet Reservoir is located in sections 6, 7, 8, 16, 17, 18, 19, 20, 21, and 28, township 52 north, range 82 west, of the sixth principal meridian in Wyoming.

Very respectfully, your obedient servant,

FRED BOND, *Assistant Engineer.*

Capt. H. M. CHITTENDEN,
Corps of Engineers, U. S. A.

Table of estimates.

CLOUD PEAK LAKE SITE.

25,015 cubic yards earth, at 50 cents	$12,508
10,900 cubic yards loose rock, at 70 cents	7,630
200 cubic yards masonry, at $10	2,000
300 cubic yards stone excavation, at $3	900
3,446 pounds iron, at 16 cents	551
One 3-foot sluice gate	200
7 miles roadway, Piney to Cloud Peak Reservoir, at $150	1,050
Total	24,839

PINEY SITE.

63,477 cubic yards of earth, at 40 cents	$25,391
30,120 cubic yards of loose rock, at 80 cents	24,096
431 cubic yards of masonry, at $8	3,448
7,878 pounds iron, at 15 cents	1,282
320 cubic yards stone excavation, at $3	960
Two 3-foot sluice gates, at $200	400
7 miles road to reservoir, at $100	700
Total	56,277

LAKE DE SMET SITE.

Upper discharge canal:		
125,209 yards earth, at 20 cents	$25,041	
3,550 yards earth in tunnel, at 50 cents	1,775	
1,000 yards concrete, at $6	6,000	
1 sluice gate in place, 6-foot	300	
		$33,116
Lower discharge canal:		
159,407 yards earth, at 20 cents	31,881	
3,550 yards earth in tunnel, at 50 cents	1,775	
1,000 yards concrete, at $6	6,000	
1 sluice gate in place, 6-foot	300	
		39,956
Supply canal:		
105,560 yards earth, at 12 cents	12,667	
66 yards rubble masonry, at $6	396	
18 yards concrete, at $6	108	
Two 6-foot iron brass-mounted gates	550	
		13,721
450 acres land submerged by reservoir, at $5		2,250
66 acres for right of way for supply canal, at $20		1,320
25 acres for right of way for discharge canals, at $5		125
1 wooden bridge at county-road crossing		200
Total		90,688

APPENDIX C.

MONOGRAPH BY MR. JAMES A. SEDDON, ASSISTANT ENGINEER, ON RESERVOIRS AND THEIR EFFECTS ON THE FLOODS OF THE MISSISSIPPI SYSTEM.

(With two plates).

I. The Mississippi and its tributaries above Cairo.
Plate I. Floods in the Mississippi system, 1880–1885. Stages and discharges of the Mississippi, Missouri, and Ohio rivers, showing the combinations that make up the final floods at Cairo, with map showing the subdivisions of the system and their respective drainage areas.

I. The Lower Mississippi.
Plate II. Floods in the Lower Mississippi, 1882, 1883, 1884, 1892, 1893, 1897. Stages and discharges at points of maximum outflow and inflow from Cairo to Vicksburg, showing the free and restrained outflow and the resulting changes, with map showing the levee lines and districts subject to overflow, with areas of the respective swamp basins.

I. THE MISSISSIPPI AND ITS TRIBUTARIES ABOVE CAIRO.

(Plate I.)

The effect on floods in the Mississippi River and its tributaries that systems of reservoirs at any of the head waters may have is wholly a question of fact. The very simple deduction that the excessive volume of a flood may be so withdrawn, to be returned when the river has reached a lower stage, is only valuable in cases that in some degree correspond with the very simple assumption that the excessive volume at the point where it is withdrawn is an element in the excessive volume that makes the destructive flood below. And where this flood below is the combination of even two rivers, it is not by any process of deduction but only in a study of the data that we may see that a proposed artificial combination of one or both is likely to materially reduce the flood extremes of the natural combination.

That these natural combinations alone form the basis for conclusions of any value in such a case as the Mississippi system is self-evident, draining as it does an area of more than two fifths of that of the United States, reaching from the Rockies to the Alleghenies and from the Gulf to the northern divide—extending through some 34 degrees of longitude and 20 of latitude, with a wide range in its climatic conditions and all of those formations which determine the proportions of run-off to rainfall, and with high waters, in its main branches even, in sight from a week to the better part of a month before they form their final combinations in the Lower Mississippi.

The general combinations forming the floods in this system are therefore shown on the accompanying plate as far as the data taken cover the problem. It is one that requires not only the stages in the rivers, given by gauge records, but the discharges or volumes of flow corresponding to these stages. As reservoirs do but take a given volume from the flood excess, all the questions here include a question of volume, and no attempt is made to carry this study farther than the discharge data go.

The map accompanying this plate shows the Mississippi drainage system, and on it the range of this study may be noted. It extends up the Missouri River to Sioux City, subdivided into the upper, middle, and lower basins, and rests on the various series of discharge observations taken in that river from 1879 to 1883. The Upper Mississippi, with the same subdivisions, reaches to Prescott, at the mouth of the

St. Croix, and is covered by the series of discharge observations of 1881. The Middle Mississippi is given by the observations at St. Louis through the same year. The 1882 series at Paducah give the final discharges of the Ohio River basin as a whole, data for its subdivisions not as yet having been taken, while the combination of the Ohio and the Middle Mississippi at Cairo rests on all the series of discharge observations taken in the reach below, as far down as Memphis, and from 1858 to 1885.

In point of time, the six years from 1880 to 1885 have been selected for this study. It is a period fairly covered by the observed discharges, and includes about the extreme and average combinations of which we have anything like definite records. It might have been extended, but to do so would be little more than needlessly to multiply data; and as it is, the period covers a group of extreme floods from the Missouri, Upper Mississippi, and Ohio rivers, and includes those phenomenal high waters at Cairo in the years 1882, 1883, and 1884.

These floods in each river, as, indeed, about all the floods of which we have definite records, have been the subject of more or less special study, and to follow the data into anything like the detail of some of these studies would but obliterate its general relations, which in this case are of first importance. The aim in preparing this plate has been to bring together the coincident phenomena of stage and discharge over the Mississippi system through this period of six years, showing, as immediately as possible, all the essential combinations in it in their summations and their differences.

Further subdivisions might have been made of both the Missouri and Upper Mississippi rivers, and it is to be regretted that the data are wanting for some subdivisions of the Ohio, but as far as they go the localities at which the stages are platted and the discharges shown give about as much of the character of the floods in each river as is consistent with the main purpose of tracing their combined results.

These hydrographs, or traces of the daily stage, given by platting for each point the gauge readings as ordinates to a common scale of time as abscissæ, show, roughly, the movements of the floods down. For instance, the very slow movement in the Upper Mississippi would be at once noted in contrast with the more rapid movement in the Missouri, and, indeed, on the Missouri the general interval of about four days from Sioux City to Kansas City, and three days from there to St. Charles, may be fairly seen in the time between the flood crests at these points, as also the special retardation of that crest in the great overflow of 1881. But the further interval of about three days from St. Charles to Cairo is hardly suggested in the diagram.

In detail, this flood movement is studied in gauge relations, the readings on an upper gauge being platted as ordinates to those on a lower as abscissæ, with assumed time intervals, until by successive approximations the interval that corresponds to the movement of the flood wave as a whole is reached and the character of this movement shown. In this way the observed discharges may be carried from point to point in a river and the increments of the smaller tributaries between such points estimated quite accurately, but even in the reaches over which such studies may be carried only an obscure view of coincident phenomena is had, and it is lost sight of entirely when it comes to the combinations of floods in a system of rivers.

The same objection holds to the method in which discharge data are studied. The observed discharges at any point are platted as abscissæ to the gauge readings as ordinates, and the variation of discharge to

gauge traced through them gives a local discharge curve. The relation of the readings on this gauge with others above or below having been determined by gauge relations, the character of the flood movements seen, and the tributary increments estimated, either this local curve or the observed discharge here may be brought into comparison with curves and discharges at other points of the river and at other times, and in a general study about all the discharge data of a river are brought together in this way to be compared and checked. But in this method it is difficult to follow the sequence of discharge anywhere, and it has to be continually worked out and platted as variations to time, even in the local comparisons.

In bringing all this mass of data together, therefore, for a comprehensive view of the whole system of rivers the methods of these detailed studies are not at all suitable, nor are they here necessary. The special character of flood movement is not so much in question in this case as its results, shown in the different stages as we go down the system, while the corresponding values of discharge are but taken from the detailed studies of those data and shown on these resulting stages.

The method is easily followed on the plate. On the vertical line of a given day all the stages and discharges of that day from Sioux City or Prescott to Cairo are shown. First in order, down come the three subdivisions of the Missouri—the upper, Sioux City; the middle, Kansas City, and the lower, St. Charles. Next come the corresponding subdivisions of the Upper Mississippi—the upper, Prescott; the middle, Clayton, and the lower, Grafton. Below, the sum of St. Charles and Grafton makes the Middle Mississippi, shown in the stage and discharge at St. Louis, followed by like data of the Ohio River at Paducah, giving finally the sum of the Middle Mississippi and Ohio in the stage and discharge at Cairo, while these data of each day are shown on the plate in sequence for every day of the six years covered by this study.

The vertical ruling shows the months and divisions of ordinary hydrographs, while the horizontal ruling shows the uniform scale in intervals of 2 feet, to which all the stages are platted. The scale of stage for each station, however, is shown from a given low-water discharge level, in the place of taking it from the arbitrary zero of a gauge, while at the same time, above this low water, the levels of uniformly increasing discharges are taken from the detailed studies and marked as a discharge scale. The variable intervals of stage between these levels, corresponding to the uniform differences of discharge, are also drawn through all the floods of the period at the given station, and, for convenience of reading, alternate intervals are shaded. Thus, on any day at any station the stage may be read direct on its uniform scale and the discharge estimated between the given intervals on its variable scale.

The discharges of the low-water levels at St. Charles and Grafton, of course, sum up the discharge of the level taken for low water at St. Louis; and, again, St. Louis and Paducah give the discharge of the low-water level at Cairo, while the arbitrary differences on the scales of discharge above these levels have been taken to correspond with these natural summations in the main rivers. Thus the scale interval is 50,000 cubic feet per second on the Missouri and Upper Mississippi, and when they come together it is doubled, giving 100,000 for the Middle Mississippi, with a like interval for the Ohio, and again doubled at Cairo, where these two rivers unite to form the Lower Mississippi. Values on the scales are written in the customary units of 1,000 foot-seconds.

These discharge scales, or respective levels of given differences of discharge, are taken from the local discharge curves, and each represents what has come to be called an average, or normal plane. That at different times there are different values of discharge at the same stage has long been recognized. For instance, the observations show almost uniformly a larger value of discharge on a rising than on a falling river, and such differences have been mainly studied as differences, or changes of plane. They run through periods, and change from one side of a normal curve to the other from causes that are as yet very imperfectly understood. They are, however, clearly not constant in their discharge difference, for generally as the discharge is larger these differences in discharge are seen to be larger also, but with the exception of low water they are very well expressed by a constant difference on the gauge scale, the increase of the differences corresponding to the normal increase of discharge with stage. They might, perhaps, have been fitted equally as well by percentages of the discharge, were there any good reason to justify the use of this much more laborious process, but, lacking that, in their study they have been generally expressed in this gauge difference as a change of plane. Thus the larger discharges on a rising river may be discharges on a plane half a foot below normal, and the falling river on a plane half a foot above; and in that case, the total difference between the rising and falling river at each stage would be the normal difference of discharge there for a foot of stage.

Besides these changes of plane, which are held to be characteristics of the floods and their combinations, there are low-water differences in the discharge of a given stage which are held to be strictly channel changes. The extreme, a total change in the regimen of the reach in which the gauge is located, of course, may result in a permanent change in the normal discharge curve there, but in general the building up or moving down of a bar has only a more or less well-defined local effect on the low-water stage, and the actual discharges of the low-water levels must be taken subject to such variations. In the upper rivers, also, which are generally frozen over for several of the winter months, and open with more or less forming and breaking of ice gorges, the sequence of gauge readings is often so irregular that we would infer a very irregular relation of discharge to gauge, and in the lack of positive data can give no definite estimate of its value. No attempt has been made, therefore, to carry the discharge scales into the extreme low waters of these periods. And further, in addition to these local low-water variations, there seems to be, at least in the Missouri River, a tendency of high floods to clear out the whole low-water bed, giving all along the river larger values of discharge in the low waters following these floods than correspond to the same stages in general, while in the same way when the floods have been low for a period of years the low-water values of discharge at given stages are abnormally small.

All these causes combine to give to the discharges of a given stage at different times their recognized differences. Some of them may be roughly estimated; thus the scales, or the normal curves from which they are taken, are likely to undervalue the actual maximum discharge of a flood, even where they accurately represent its average across the crest. And again, if we wished to approach somewhat nearer the actual discharges through a rise, we might take a lower plane for it from a few tenths to perhaps as much as a foot, and by adding that much to the observed stages, read its discharges on the normal scale, following a reverse process through the fall. But very generally in

double rises, and sometimes from one flood to another, changes of plane occur that are still almost wholly a subject of speculation, while the local low-water changes, though small in their discharge error, are everywhere only a question of fact. But even where this whole subject is covered by reliable discharge observations it is a most difficult problem to trace out the elements of these changes and determine their magnitudes, and it is well to understand at once that in default of such positive data at the time, in general no closer approximation can be made than this average value of discharge, and a closer agreement than this warrants, in summing its combinations, is not to be expected.

With this recognized, some of the more prominent combinations may be now noted. Take, for instance, the high-water crest of June–July, 1880, on the Missouri. We see the general value of discharge 150 at Sioux City, something more at Kansas City, and about 200 at St. Charles. On the Upper Mississippi, 100 at Prescott, 200 at Clayton, and between 250 and 300 at Grafton. The combination of St. Charles and Grafton gives something less than 500 at St. Louis, which, with something more than 300 from the Ohio, makes up the 800 discharge of this crest at Cairo.. The highest water of this year at Cairo, however, occurs in the latter part of March, with a discharge of something over 1,200, about 1,000 of which we see at Paducah and 100 at St. Louis, leaving 100 difference, some of which is drainage from the watersheds between St. Louis and Cairo, and some of which may be this error of discharge values.

Again following down the crest of the great flood of 1881 on the Missouri, we see that it is well above the 500 value of discharge at Sioux City and Kansas City and barely 500 at St. Charles. This showing of a reduced discharge may have been a result of its exceptional overflow, filling as it did from bluff to bluff the whole valley to well below Kansas City; yet it must be noted that no discharges at any such high stages have yet been measured at either Sioux City or Kansas City, and the scales there are only carried up with the rates of lower observations. It is also not uncommon to find in general discharge data a check to velocity as we pass above this stage of overflow, and this is here suggested by the peculiarly retarded movement of the flood wave down the river. This showing must not, therefore, be taken as conclusive of a reducing discharge.

Continuing this period down, the something under 500 discharge at St. Charles with the something over 300 at Grafton give about the 800 at St. Louis, which, with something under 500 at Paducah, should give nearly 1,300 for Cairo, in the place of the something under 1,200 shown here. This excess indicates an abnormally low plane at Cairo or an abnormally high plane above; but whichever it is we have only to go back some twenty days to the main crest at Cairo to find the flow again corresponding with the normal planes, and 550 at St. Louis, with 750 at Paducah, give the 1,300 at Cairo, while again St. Louis is made up of something over 250 at both St. Charles and Grafton. The St. Charles here is a combination of headwater rises, which would certainly show a reducing discharge down did we not know that at this time it was so mixed up with ice gorging that little in the way of definite conclusions can be drawn from it, while it is seen that the Grafton flood comes in almost wholly from below Clayton.

These subdivisions of the Upper Mississippi above Grafton require special notice. While the stages and discharges were observed at Prescott and Clayton from November, 1880, to the latter part of October, 1881, the stages for the six years covered by this study were neces-

sarily taken from the regular gauge records at Hastings, 3 miles above Prescott, and Prairie du Chien, 14 miles above Clayton. These records, respectively above the St. Croix and Wisconsin rivers have the necessary defects of a gauge so located with regard to a tributary. However, through the year in which comparisons could be made with the gauges of discharge parties these defects were considered fairly within the possible error in any normal value of discharge, and in the case of Prescott it would certainly hardly ever exceed this; but in the case of Clayton it can not be said that there were no serious changes of slope in the 14 miles between the gauges, even though none occurred in the year covered by readings on both. To this extent the discharges at Clayton are subject to this possible additional source of error in all except the 1880–81 period. However, it cuts no figure in the general combinations of the system, and it serves its purpose very well in showing that the flood of the Upper Mississippi is mainly formed in the Grafton drainage basin.

Following 1881, which is the only instance known where a head rise from above Sioux City has reached anything like such volumes, 1883 shows the more general type of high flood in the Missouri. The regular June rise in that case receives large contributions from both the middle and lower basins, and as we should expect, combining with like contributions from the Grafton basin, continues the high water into the Middle Mississippi. But it comes altogether too late for the flood season in the Ohio, and the combination in the Lower Mississippi is some 13 feet below extreme high water.

This is also a case in which the summations of the scale values of discharge can not be reconciled. It is clearly over 800 at St. Louis, both from the St. Louis values and the sums of the St. Charles and Grafton values. But this, with the nearly 400 at Paducah, should give 1,200 for Cairo, while we see that it reads barely 1,000 on the Cairo scale. Whether the plane of flow at Paducah was abnormally high or at Cairo abnormally low, or what combination of these two existed, is simply a matter of speculation. The extreme high water, however, of February in that year agrees very well, about 200 at St. Charles and 300 at Grafton, making the 500 at St. Louis, which with more than 1,200 at Paducah, give the 1,700 or more at Cairo. And this, like great floods in general in the Lower Mississippi, is almost wholly an effect of the Ohio River, while even the 500 from St. Louis comes mainly from the St. Charles and Grafton drainage basins.

The great floods at Cairo of 1882 and 1884 show even more strikingly than that of 1883 this preponderance of the Ohio River effects. True, the extreme of the 1882 flood at Cairo is given by the sharp rise to something over 500 at St. Louis, coming upon Paducah over the 1,200 mark, again combining to give a Cairo crest closely approaching 1,700. But the great body of this flood is wholly from the Ohio, and the total contribution from the Middle Mississippi is almost insignificant. And again in 1884 the 1,700 point is reached at Cairo with over 1,400 from Paducah and less than 200 from St. Louis.

As we have summed up the crest discharges, so we may sum up the hollows between them, or the low-water periods, and indeed, allowing the proper intervals, carry the comparison from day to day through the whole of the six years covered by the study. In all this we will find in the main an essential agreement within the limits of those errors whose sources have been noted. But perhaps the last two years of the St. Charles data deserve a special notice. There, during the flood of 1884, in the reach just above the gauge, occurred one of those radical changes

in the regimen before referred to. The river in that case left its old channel around the St. Charles Island and shortened its course by several miles. But the data here show at least no very considerable error in the use of the old normal curve, and some discharge observations taken about six years later indicate that whatever may have been the change at the time, there was but little of it permanent.

From the general review of the data shown on this plate we may here turn to the more special question of tracing on it the effect of reservoirs. The 1,000 cubic feet per second used throughout as the unit of discharge is 86.4 millions of cubic feet a day, or a square mile covered to a depth of 3.1 feet. A convenient unit of capacity may be therefore taken as a square mile of reservoir surface filled through 31 feet, which is equal to a value of 10 on the discharge scales through one day. Thus, for each day the 50-scale interval in the discharge of the upper rivers is equal to 5 square miles of reservoir surface filled through 31 feet, while the scale interval is four times as much for each day at Cairo.

With these equivalents we may easily reckon the capacity required for a given reduction of any flood. Thus, to bring the flood of 1881 at Sioux City down to the level of a 400 discharge, we read there the excess above 400 for each day, approximately, as follows:

Day	(1)	(2)	(3)	(4)	(5)	(6)	} 560
Excess	80	130	140	120	80	10	

Or it would have required an available reservoir capacity above Sioux City of at least 56 square miles, 31 feet deep, and we see that the corresponding reduction in stage in that case is 2.8 feet.

Again, to cut down to 400 in the Missouri the flood of 1883. At Kansas City we have the following excess:

Day	(1)	(2)	(3)	(4)	} 80
Excess	10	30	30	10	

Or eight of our units of reservoir capacity, reducing the stage there 0.7 foot. At St. Charles the stage must be reduced 3.9 feet, and the excesses are:

Day	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	} 1,550
Excess	20	50	70	110	140	160	180	180	160	130	100	90	70	60	30	

From this the 80 excess at Kansas City must be taken, leaving finally 147 square miles 31 feet deep for the capacity required in the St. Charles drainage basin.

True, some of this St. Charles excess might have been taken off in the Kansas City drainage basin, if it had been taken off in the right time, and again, with the same proviso, some of both the Kansas City and St. Charles excess might have been taken off in the Sioux City Basin. But the highest water of that season at Sioux City is not reached until two weeks after the crest considered has passed St. Charles, and had the reservoirs in that basin been filled from this high water, they would not have had the slightest effect in reducing the flood extreme below. Indeed, we have been only calculating the least reservoir capacity for a given reduction, assuming that the reservoirs in their respective drainage basins could be so used as to effect this, requiring them to be filled at the proper times and at rates corresponding to all the changes in the values of the daily excess.

Of course it is evident that such a perfectly efficient operation of reservoirs in any drainage basin could not be attained, and even for a fair degree of efficiency the study of floods would have to be carried much nearer their sources than they have yet been; but as it is only a

question of collecting and studying the data to carry these even up to their origin in the rainfall, we may suppose that in time a system of reservoirs may come to be operated with some approach to the efficiency of these calculated effects.

And while it is much less probable that a system of upper reservoirs could be used to reduce the flood excesses of rain that had not yet fallen in a lower basin, and that unless the reservoir system was continued down, reducing the lower flood extremes with it, would be more and more a matter of chance. Still, probably for the Missouri River, a comprehensive system of reservoirs in the Sioux City and Kansas City basins might be counted on to materially reduce the volumes of its excessive floods, and this, from the capacity of any given system, may be easily reckoned on a basis of perfect efficiency.

What the actual efficiency in their operation at first might be is largely a matter of guesswork, as it involves problems that time and experience alone can solve. But assuming that the unstudied movements of floods at their sources present no unforeseen difficulties, we may take the final efficiency of operation as a fraction something over half the perfect efficiency, and perhaps as much as three-quarters of it, and trace on that basis actual reductions of volume and stage to St. Charles. From here in the enlarged channel of the Middle Mississippi this effect on flood stage is materially reduced, and a new element of chance enters into its combinations with the Upper Mississippi. But the high-water crest at St. Charles in general coincides with the crest at St. Louis, and were a system of reservoirs also constructed in the Grafton drainage basin they could probably be operated in harmony with the Missouri systems.

However, with or without this Grafton system, which is evidently the only one that could be brought to materially affect the final volume of floods in the Upper Mississippi, it is seen at once that the whole of these effects are utterly obliterated when we come to combine the Middle Mississippi with the Ohio. Not only is the volume of the St. Louis flood much smaller than that of Paducah, but the wide interval between their periods can hardly be said to leave a chance of the main flood from the Middle Mississippi coinciding with the main flood from the Ohio, which makes the high-water crest from Cairo down; while such floods as 1881 or 1883 at St. Louis, striking as they do on secondary crests at Paducah, are wholly insignificant in the high-water stages of the Lower Mississippi.

Possibly an upper system in the Grafton and St. Charles basins could have been used in some small way to mitigate the flood extremes at Cairo in 1882 and 1883, by cutting down the early rises at St. Louis that correspond with them. But such a use of reservoirs might conflict with their usefulness in reducing the flood extremes of the basins in which they were located, and would have in their lower river effects a large element of chance; while in 1884 about the same extreme is reached at Cario with little more than an ordinary low water at St. Louis.

It is evident, therefore, that if we look for head-water reservoirs to effect any reduction of flood extremes at Cairo, we must look for them wholly in the Ohio River basin, and until the discharge data are taken for a suitable subdivision of this river, and the volume of its flood traced back in some degree to its sources, whatever systems of reservoirs may be proposed here and whatever may be possible, very little can be predetermined in regard to the effects that they might have on flood extremes.

II. THE LOWER MISSISSIPPI.

(Plate II.)

So much for the direct effects of head-water reservoirs; but these direct effects are not all of the question. In a large part of the Mississippi system, where the rivers lie in alluvial valleys of their own deposits, to change materially the extremes of volume would naturally cause some change in the whole regimen. In the Lower Mississippi, where overflow from point to point causes such changes in the extremes of volume, there is noted at once a corresponding difference in the range from low to high water, a difference from more than 50 feet in the one case to less than 40 feet in the other. But this in itself leaves the question still open whether the loss of volume had lowered the natural high-water level or raised the natural low-water level, or what combinations of both it had caused.

While all this has long been a subject of controversy, it would not have been taken up here were it not that the data of the Lower Mississippi are beginning to contribute something in the way of facts to this field speculation. It is not necessary to speculate about what would be the effect of withdrawing a flood excess, for that is exactly what we have in the earlier conditions of the Lower Mississippi, and in the changes accompanying the more completely leveed river of to-day, what is at least beginning to be a measure of this effect is given. While, therefore, the study of floods has been brought down to Cairo with the main purpose of simply tracing their volumes and their general combinations, in carrying the study from Cairo down the main purpose is to see the effects that the withdrawal of flood excesses may have on the regimen; and for this a group of the earlier floods are brought in contrast with the more completely leveed floods of later years.

Plate II presents the data, with map showing the Mississippi River from Cairo down and the areas subject to overflow at high water. Upon the west bank, from Cairo to Helena, lies the St. Francis Basin, while the Yazoo extends from Memphis to Vicksburg, on the east. Below the bluffs at Helena, on the west, lies the small area known as the White River Basin, ending a little below the Arkansas River, where the Tensas Basin begins, extending down to Red River. Below the Red River, on the west, the overflow area is known as the Atchafalaya Basin, and on the east, from where the bluffs finally leave the river, as the Pontchartrain.

In general all along these basins the ground slopes back from the Mississippi into an area of low swamps threaded with lakes and bayous and draining into such rivers as the St. Francis and Yazoo. Thus as the Mississippi rises above the bank-full stage the flood excess is drawn off into these swamps, which act so far just as a system of great reservoirs. As, however, all the upper basins have their natural drainage back into the Mississippi, it is only above this return that the reservoir action is complete, while at their lower ends they do not hold but only retard the movement of the flood excesses that have been drawn off above.

The time that this overflow is held back probably differs to some degree with the stage and duration of each flood, and it is only roughly estimated in the interval between the crest of the flood above the basin and the crest of the swamp return flow at its foot. It may, however, be generally taken for the St. Francis or the Yazoo as about two weeks

in each case, and these basins are thus equivalent to two great reservoir systems that draw off the flood excess along all their upper boundary and return it to the Mississippi at their lower ends after this time, though in addition to this there are also large areas that are simply flooded to a level and can only be drawn down as the river falls.

The dividing line for the St. Francis basin between this general outflow and inflow is probably a little below Memphis, though the difference in stage and discharge between Cairo and Memphis is the best measure to be had of total outflow; and again, between Memphis and Helena, of total inflow. The inflow in that case, however, is evidently not a total, since the outflow into the Upper Yazoo at the same time is necessarily lost to the Helena stage and discharge.

Farther down Lake Providence and Vicksburg hold respectively about the same relation to the Yazoo basin that Memphis and Helena do to the St. Francis, Lake Providence showing the extreme of outflow and Vicksburg of inflow; but the conditions here are evidently much more complicated. First, the outflow into the Upper Yazoo between Memphis and Helena is not directly shown upon any gauge; then, the filling and emptying of the White River basin, with the additional water from the Arkansas and White rivers, draining as they do one of the great subdivisions of the Mississippi system, all together combine to obliterate the effect of the further overflow into the middle Yazoo between Helena and the mouth of White River; and, finally, while the differences in stage and discharge between the mouth of White River and Lake Providence show the total outflow in that reach, there is no way of there separating the outflow into the Lower Yazoo from that into the Upper Tensas.

About the best that can be done, therefore, with the Yazoo basin is to take for it the mouth of White River as a second initial point, as Cairo was taken for the St. Francis. In that way something of the outflow is shown by the differences in stage and discharge between the mouth of White River and Lake Providence, and probably more nearly the full inflow in the differences between Lake Providence and Vicksburg. Indeed, this last measures the same sort of an approximate inflow that the difference between Memphis and Helena measured for the St. Francis; that is, less than the full inflow by the simultaneous outflow into the Tensas between these gauges.

Farther down the conditions become even more complicated, and with the alternating inflow and outflow at the head of the Atchafalaya accompanying the relative changes of stage in the Mississippi and Red rivers the sequence of discharge down the Mississippi is difficult to follow, even within banks. But it is really the changes of plane that rise in this lower part of the river that effectually bar the further progress of this investigation, for they so break up the relations of discharge to stage that to go into the data here would necessarily involve another and a totally different study.

This study of floods in the Lower Mississippi, therefore, ends at Vicksburg. It covers the three earlier floods of 1882, 1883, and 1884, in contrast with the later floods of 1892 and 1893 and the last great flood of 1897. Stages and discharges of these are shown on Plate II in the same way that they were shown for the upper rivers, and at each of the characteristic points from Cairo down, between which the nature of the outflows and inflows and their relations to the different basins have been noted. Here, then, on the data of Plate II, in the differences of discharge from point to point, the magnitude of these inflows and outflows at any time may be read immediately in actual units of flow,

while between the earlier and later floods the change in these magnitudes as the basins are shut out with levees may be at once seen.

While the former method is essentially followed in showing the data on Plate II, it may be noted that stage is here given in its actual gauge readings and not from the level of an assumed low water, while the discharge scales uniformly begin at the level of the hundred thousand cubic feet per second, and marked discharges successively increasing by that amount. Further, in this case, the alternate shading of Plate I is again alternated with a cross shading, to make the levels of the same discharge stand out as distinctly as possible all the way down.

Except between Helena and the mouth of White River, where the drainage from the Arkansas basin may add materially to the discharge, there is, of course, little difference in the natural discharge of the river as we go down. Some local drainage comes in on the east between Cairo and Memphis, and for a short time after, heavy rains may make the Memphis discharge perceptibly larger, but in general they are practically the same as Cairo. In a like way, and to a somewhat greater extent, the natural drainage of the St. Francis may swell the discharges at Helena and again the Yazoo at Vicksburg. But, bearing all this in mind, in general the identity of discharge all down the river, from low water up to the level of overflow, may be traced at once on these discharge scales.

Thus at the beginning the low water of 1881 shows about 125 from Cairo to Memphis, probably 130 at Helena, 140 to 145 below the Arkansas, and somewhat larger at Vicksburg. Or again, on the crest following, a little less than 800 from Cairo to Helena with about 850 from mouth of White River to Vicksburg, followed by the fall to just 400 from Cairo to Helena, and about 500 from mouth of White River down.

In this last case the 100 increase in the scale of value of discharge between Helena and the mouth of White River may seem large, and observed discharges might also have given a smaller actual difference, for special studies have shown that a rise of plane often accompanies inflow from the Arkansas under these conditions, and such an increase of stage above the normal, of course, reads as an increase of discharge on our normal scales. But it is to be noted that this 100 difference shows not only on the scale at the mouth of White River, but also at Lake Providence and Vicksburg, and in that case whatever part of it may have been a rise of plane at the mouth of White River the same part must also have been the same rise of plane from there to Vicksburg.

Indeed, it is altogether this double identity of discharge and plane that is traced down in the scale values. Though the actual values of discharge may be larger on the rise and smaller on the fall, so long as they differ from the normals by the same amount all the way down their normal values are the same. It is only because of this general continuity of plane underlying the phenomena of flow in the Lower Mississippi that the identity of discharge can be traced at all in the data from point to point; for as the higher stages are reached it is well known that the extreme differences in observed discharges may be several times as large as the 100 interval of our discharge scales, and the fractional differences that may still show from point to point are not at all representative of the actual differences in the planes of flow here.

It is unnecessary to go through all this in special periods: the identity shows up immediately all along the plate at each low water and at all the extremes of rise or fall above low water; and while it does not here show so distinctly during the progress of a rise or fall, still

extended studies in gauge relations have shown that this identity may be traced from day to day through the whole flood within banks, over hundreds of miles, to the nearest tenth of a foot in stage and tenth of a day in time; and certainly hydraulic phenomena furnish few instances of more exact relations, subject, of course, to the tributary increments noted, and again on the falling stage, after overflow, further subject to the drainage of flooded areas, that may be held as backwater until the river falls.

Passing, therefore, at once to the flood periods, the group of floods 1882, 1883, and 1884 may be taken as giving about a condition of complete overflow. There the outflow into the St. Francis is shown in the extreme of 1,700 at Cairo, cut down to about 1,200 at Memphis, and again brought back by inflow to about 1,400 at Helena, which, as noted, is less than the total extreme of inflow by the simultaneous escape into the Yazoo. The level of 1,000 on the discharge scales may be generally taken as about the beginning of outflow, and in this reach it seems to be complete at about the level of 1,200. That is, all that comes down in excess of this goes out into the swamp; thus crests of 1,700 at Cairo are cut down to about 1,200 at Memphis, just as crests of 1,400 are. But in May and June, 1882, crests of 1,100 at Cairo are evidently cut down very little by outflow to Memphis, while in April of 1883 a crest of 1,200 is cut down to 1,100; or between the beginning at 1,000 and the general level of 1,200 the outflow is only partial, and probably becomes less and less as the crest approaches Memphis. The fact that the second crest of 1884, above 1,400 at Cairo, shows less than 1,200 at Memphis may be due either to a change of plane or to the cutting out of some crevasses in the high water preceding it, and thus a real excess of outflow.

With these changes in the flood crests the filling up between crests goes on; even between Cairo and Memphis the flooded area on the east must be drained back as the river falls, holding up in this way the stage and discharge at Memphis. Indeed, in March, 1882, some of this outflow seems to have been carried down as a true swamp flood, coming out on top of the high water in a distinct crest at Memphis, corresponding with outflow of the crest at Cairo, and again with its return at Helena as St. Francis inflow. This overflow, however, in general but serves to swell the volume of falling stages at Memphis and more or less to fill up between the crests, to which, probably, some overflow on the west that does not get back into the swamp also contributes. This action may be traced through the fall of April, 1882, checked by the rise in May, and filling up again between the following crests of June and July, while to some extent, even, it shows through the extreme fall of March, 1883, and notably between the first and second crests of the flood of 1884, in which case, with less than 900 at Cairo, the river does not quite fall to the 1,000 level at Memphis.

This filling up at Memphis is, of course, continued to Helena, and indeed is much more prominent there, as it has also at that point the whole lower part of the St. Francis Basin to draw on, while upon this leveled-off flood in the main river the crests of inflow from the St. Francis come in, lagging behind the Cairo crests which formed them by something like the two weeks that it takes them to pass down that swamp. Thus in 1882 the double crest of inflow at Helena corresponds with the two crests of outflow from Cairo, and in the same way the single crest of 1883, and again the double crest of 1884. But in their scale values these inflows do not in general give the same extremes of discharge that the outflows do.

It is true that the first crest at Cairo in 1882, which stands above 1,400 for more than ten days, comes back in inflow to about 1,400 at Helena; but the second crest, which reaches an extreme of some 300 more discharge at Cairo, shows only a fraction above this 1,400 in its return flow; and while it is very certain that in this period all obstructions to outflow on the Upper Yazoo front must have been swept away, it hardly seems that the outflow there could account for this large difference of 300 in the discharge.

It is quite possible, and indeed would seem probable, that this sharp crest of 1882 might have been flattened out in its passage down the swamp, did not the same discrepancy show in the crests of 1883 and 1884, neither by any means sharp crests, and, in fact, that of 1883, almost of the same duration as the first crest of 1882. There is good ground for belief, therefore, that through these crests of inflow the discharges at Helena are decidedly larger than their scale values, and the observed discharges there bear out this conclusion. Indeed, such observations all along the river show generally that between the draw of large crevasses below on the one hand and the lake-like character of points in the complete overflow on the other there may be wide divergencies from any uniform variation of discharge to gauge. That continuity of plane which at the lower stages made the scale values of discharge at least true in their differences is thus more or less broken up in this period of overflow, and from Helena down these scale values must not be taken as a measure of the possible extremes, but only as rough averages for the whole period.

In the reach below Helena this is so prominent that for high water at Lake Providence the decreasing intervals of stage on the regular discharge scales are in that case actually reversed. While the regular scales at mouth of White River and Vicksburg probably undervalue their crests of inflow, as they do at Helena, any such continuation of a regular scale at Lake Providence would so greatly overvalue the whole mass of observed high-water discharges there that an actual break has to be introduced about at the bank-full stage to represent anything like what is known to be an average discharge. This scale here at times clearly undervalues the discharge; thus on the front of the 1882 flood, while the 900 level is reached about December 31 at mouth of White River, January 2 at Lake Providence, and January 3 at Vicksburg, the 1,000 level is given about January 8 at mouth of White River, January 18 at Lake Providence, and January 11 at Vicksburg; and certainly the 1,000 discharge must have then reached Lake Providence about January 10, or at least a foot lower than the scale level. But again, from about the middle of May to the middle of July in this flood a mass of observations shows the discharge as barely 1,000, and this lower scale would have greatly overvalued it, while from the same series of observations there is little doubt that on the crest about March 20 the Lake Providence discharge was rather below 1,000 than above it. This last, however, is one of the rare periods where the river actually rises at Lake Providence from the back-water action of an inflow at Vicksburg.

With these limitations the general action of outflow and inflow may be traced through the discharge values from Helena down, though, as noted, with the outflow into the middle Yazoo on the one hand, and on the other the filling and emptying of the White River Basin, with the addition of all floods from the White and Arkansas, but little can be made of the elements causing the changes shown between Helena and mouth of White River. The continued filling up between crests, back-water drainage on the falling stage, and a general reduction of the

flood extremes from the level of 1,400 at Helena to a little over 1,300 at mouth of White River may be noted. However, it is here, in the fact that the floods from the Arkansas and White rivers, large as they are, seem almost to be lost on the top of these floods at mouth of White River in comparison with the effects of inflow at Helena and Vicksburg, that the immense volumes of these inflows from the St. Francis and Yazoo are best realized.

But following the discharge scales, the extreme of 1,300 at mouth of White River is again reduced to less than 1,100 at Lake Providence and brought back in 1882 and 1884 by the Yazoo inflow to 1,400 at Vicksburg. True, in 1883, at Vicksburg, no such level is reached, but it is perfectly evident there from Cairo down that the double retardation of the swamp flood in the St. Francis and Yazoo basins is going to bring it out at Vicksburg, just about on the extreme fall between the first and second crests of that year, as the single retardation of the St. Francis pushes it somewhat off the crest at Helena. This, however, is not a common case, and in the main these inflow floods come in on the same general high-water levels from which they were taken off as outflow.

What their extremes of discharge may have been is practically indeterminate. There is no more reason to believe that the 300 difference between Lake Providence and Vicksburg is a large enough measure of the Yazoo inflow, even after all allowance is made for simultaneous outflow into the Tensas, than there was to believe that the difference between Memphis and Helena was a large enough measure for the St. Francis inflow. Indeed, with the exception of the 500 value given for the outflow between Cairo and Memphis, there is nothing that can be called even an approximate measure of the possible extremes of these swamp discharges; it is only evident that they are great floods gathering in the upper St. Francis until they reach a volume approaching to something like half of that which is left in the main river, and poured out again in the reach just above Helena in general before any fall sets in. And again the same thing is repeated, possibly even on a larger scale, in the Yazoo Basin.

It is evident in all this period from 1882 to 1884 that the levees of the Lower Mississippi offered no obstruction to an almost free overflow. Such as they were, they gave way so readily before floods of this magnitude that the swamp basins may be considered as having practically open fronts. But turning now to the floods of 1892 and 1893, it is equally evident that this is no longer the case. During this period of some eight years the levees had been built up and extended until, so far as they went, they then formed an almost complete barrier to outflow.

This system at that time consisted of the line of levees from the bluffs below Memphis to a little above Vicksburg, shutting out the whole of the Yazoo basin; the line between the Arkansas and Red rivers, shutting out the whole of the Tensas; a part of the line between Helena and White River, not as yet greatly affecting the White River Basin, and a small piece about the middle of the St. Francis, having practically no effect on the outflow there. The rest of the upper levee lines shown on the map have been built since the flood of 1893, while the history of levee construction below Red River does not concern this study. This system had been more or less complete for four or five years prior to these floods. It had met a severe flood in 1890 that had broken through it in a number of crevasses, been repaired, and about fully resisted the rather lower flood of 1891, and held as far as it went these floods of 1892 and 1893 with but few breaks, considering the strains that were put upon it.

Having considered the data generally in the discussion of the earlier floods, it will be only necessary to note the differences due to levee restraint in following these later floods from Cairo down. For the outflow into the St. Francis there is, of course, no difference at all, except the very material reduction of its volume that must follow the lower crests at Cairo in these later floods. Perhaps the small inflow wave at Memphis in 1893 is somewhat increased by the short piece of levee construction above, but all together the Cairo crests are cut down at Memphis in essentially the same way that they were before.

Between Memphis and Helena, however, the simultaneous outflow into the Yazoo is now shut off, and in 1893 the river comes back on the crest of inflow at Helena close to the discharge level of the Cairo crest, while in 1892 the greater difference is clearly due to the retarded inflow coming in between the crests of that year, as it did at Vicksburg in 1883.

From Helena to Mouth White River the further outflow into the Yazoo is also shut off, and the flood below more closely corresponds with that at Helena, though swelled in its total volume by the contributions of the Arkansas and White rivers and modified somewhat by the White River Basin. But it is in the reach below mouth of White River, where the levee system now extends along both banks and shuts off the double outflow into the Yazoo on the one hand and the Tensas on the other, that the greatest contrast with the earlier conditions is naturally to be found. Here the Lake Providence extreme is increased by something like 300, and, indeed, from mouth of White River down the whole flood begins to show something of that general identity that is the common feature below the bank-full stage, though in 1892 there is still some loss through crevasses, lowering the Lake Providence and raising the Vicksburg extremes; and again in 1893 the large breaks into the Tensas, about the end of May, let down the latter part of this flood at both points.

Here also, at Lake Providence, a marked high-water increase of discharge with stage is to be noted. Though averaging observed discharges through this period, it is still necessary to introduce something of the earlier high-water break in the form of the discharge scale; still it is less of a break, at a higher stage, and all through the high water the discharge average is decidedly larger. It is very evidently what may be termed an increase in the high-water channel capacity, and indicates the partial removal of the naturally reduced capacity that accompanied the large and uniform loss from outflow in the earlier conditions of this reach.

While this lower reach is so far the only marked instance of such an increase, it should be noted that such channel changes are very hard to determine in the high-water data. Thus at Helena, whatever may have been the increased high-water capacity there through the floods of 1892 and 1893, it certainly hardly served to balance the draw of a free outflow below through the crests of the earlier floods. More must therefore be known in general of both of these before any definite conclusions can be drawn from the difference between them, which is all that such contrasts give us.

But whatever doubt may still remain in regard to high-water changes, there is certainly now room for very little in regard to the changes that have taken place in the low-water levels; for in general along this whole line, where outflow has been restrained, the low-water planes have been lowered something like 2 to 5 feet. As it has been noted on the

Missouri River that following a series of years in which the floods have been below the average, the general level of the low-water plane is raised in some corresponding degree, or that the extreme high water is required to clear out the low-water bed, so here the greater extremes of the restrained floods but show a like effect.

And in fact all this might have been inferred, for every cutting bank or bar is continually caving into the river, throwing in this way material upon the bed that is not carried away, for there is no evidence of an increasing movement of material downstream; and, indeed, accumulating as it would, could not be so taken up in the flow without soon coming to overload it. This material is, therefore, in some way simply spread over the bottom, and at all times this must be below the existing water level. It is only then in its extreme stages that a flood can move it up on the slopes of points and bars, and throw any of it altogether out at the bank level.

While a river in all its upper part may be cutting down its bed in the slow process of geological periods, undoubtedly in the lower alluvial part it is building it up in the same process, and with its alluvial part relatively short, this action may even be perceptible in the course of centuries. But in a system where the alluvial reaches extend up from 1,000 to 2,000 miles it seems hardly worth considering, and certainly not to the exclusion of the equally palpable fact that the alluvial river is also keeping its bed down, or otherwise its channel would fill up by the fall of material into it, just as a hole in the ground; and this also in periods that in comparison to the other action are relatively immediate. For instance, in the reach from mouth of White River to Vicksburg this caving-in averages a fill of more than a foot annually over the whole 200 miles of river nearly a mile wide; and at this rate, were it not balanced annually by the clearing out of floods, a single life would be long enough to see there the channel almost obliterated, though as a fact the rate would certainly greatly decrease in the process.

It is not surprising, therefore, to find this movement of the low-water plane along the whole line of levee restraint from Memphis down to where, some hundred miles below Vicksburg, the general plane of the bed sinks below the outlet level of the Gulf and the phenomena of an alluvial river begin to be merged into the phenomena of an estuary.

It is not to be expected that such a general letting down of the low-water regimen over some 500 miles of river would be altogether regular at the ten or twelve points where it may be noted in the difference between the early and later gauge records. But in the period between 1884 and 1892 of this study it has come to show itself on all the gauges in this reach with the single exception of the mouth of White River. This exception is probably due not so much to the fact that it has there the open White River Basin on one side, for it has gone down above under similar conditions, but because at a junction like that of the Arkansas, before a change in the low-water regimen of the Mississippi can be maintained, it must work out some change in the regimen of both rivers.

Thus from 1892 on, Helena, Lake Providence, and Vicksburg show instances of this low-water change; while the mouth of White River shows the single gauge, in the range of these restrained floods, on which no such change has yet been noted. The lowered planes of the later discharge scales give the magnitude and the character of this change at these points; and it is evident at a glance that without this lowering in the discharge levels the general identity of discharge down could no longer be traced.

Thus Helena can not have a less discharge than is shown from Cairo to Memphis, and to meet this requirement within banks all the old discharge levels there must be lowered. Indeed, at Helena it has evidently not been lowered enough for the extreme low waters of 1891 and 1892, as in 1892 the discharge shows 100 at Cairo, 120 at Memphis, and 100 at Helena. This is probably too large at Memphis and distinctly too small at Helena, but it lies in the range of these local differences in low-water stage that follow the building up or moving down of bars and that are not included in these average planes.

While these low-water changes have now been under observation for about ten years, it can only be said of them that they follow, in some way, upon the showings of outflow restraint, though apparently altogether irregular in the location and the magnitude in which they may at any time show themselves. Thus, through the floods of 1892 and 1893 there is evidently no further lowering at either Helena or Vicksburg, while at Lake Providence and the reach above the effect of these floods is marked; and, in consequence, the average plane taken for Lake Providence is somewhat too low for the first part and too high for the last part of this period. It is only in the cumulative effect, through a number of floods and at a number of points, that this whole change makes itself prominent.

And here the period between the flood of 1893 and the flood of 1897 is significant. Through it the levees were extended to cover the lines now shown upon the map, but as all the floods of this period were within banks, it is marked with no restraint of outflow and no material change in these low-water planes. Thus the planes of 1893 give the fall low water of 1896 between 140 and 160 from Cairo to Helena, and between 170 and 190 from mouth of White River to Vicksburg; the December crest almost exactly 500 all the way down, followed by a fall to a little over 200 from Cairo to Helena, and almost exactly 300 from mouth of White River to Vicksburg, and finally, in the latter part of February, just before the great rise of 1897, a crest of about 800 at Cairo and Helena, and a little over 800 at Lake Providence and Vicksburg.

True, on this crest Memphis shows somewhat too small a value of discharge, and the mouth of White River too large; but like differences must be looked for on any average scale, covering such an extended period as these do, from 1881 to 1897. Though the regimen of the Lower Mississippi on the whole is remarkably stable, it is not a fact that the lower planes considered are the only changes that may occur there, nor is it so inferred that they are the effects of restrained floods; but it is because they follow such restraint, always in the same direction, showing at a number of points, and only follow such restraint, that as data they come to bear out the inference that would lead us to expect them.

The scales of 1893 are, therefore, simply carried through the flood of 1897, and within the limits noted may be fairly taken as giving the discharges of this flood and their changes. Memphis here shows the first restraint of outflow into the St. Francis. At that point the river evidently rises to about the middle of March with outflow greatly reduced by the upper levee line; but there these levees break, and the maximum of 1,400 at Memphis is drawn down, with the growing excess from Cairo, through the enlarging crevasses. The return of this at Helena brings its extreme again back to the 1,700 level; and even indicates that it might have risen higher, probably from engorgement, had not the levees there generally given way about April 4, and from that date on the flood excess is greatly reduced.

Of this reduction the Yazoo outflow comes back in the inflow crest at Vicksburg about April 16, while the effect of its withdrawal shows on the form of the flood at both the mouth of White River and Lake Providence. But in this lower reach the levees have evidently been broken at a somewhat earlier date, and the crest at the end of March gives about the limits of complete restraint. From there on the filling and emptying of the White River Basin, the flood water from the Arkansas and White rivers, the crevasse discharge into the Yazoo, to be returned at Vicksburg, with a similar loss into the Upper Tensas, all go to make up the stages and discharges shown in these flood forms.

It is needless here to attempt to value these elements, while their combined effect at any time shows for itself. It is enough, therefore, to note that the level of complete restraint gives something over 1,500 at Mouth White River and something under 1,500 at Lake Providence and Vicksburg, a difference of plane similar to that noted within banks on the February crest. And again, that the upstream effect at Lake Providence from inflow at Vicksburg shows in the corresponding crests, as it did in the 1882 and 1884 floods. And finally, though certainly a good deal of water gets out of the river, as is perhaps best seen in the Yazoo inflow, holding as it does a crest at Vicksburg above 1,600 for about twenty days, still, after all, it is only necessary to glance back from the forms of this flood to those of the earlier floods to realize how almost complete was its restraint in its passage down the river.

That such a flood will be followed by further changes in the low-water levels and probably in the high-water channel capacities is certainly to be expected. And though so far the low-water levels at the points considered show little, if any, additional lowering, still, in general, the whole effect on the river of a single flood is a subject of an extenged detailed study; and where and to what extents the effects of this flood may come to show themselves must be left for further investigation and future data to determine.

But be that as it may, the changes on the Lower Mississippi between the restrained and unrestrained floods have now gone far enough to show with little doubt that if a reservoir system could be made to considerably reduce the flood volumes and stages of an alluvial river, it would not thus simply lower the flood line, nor would the flood line alone show all of its effects, for in the final regimen large changes must be looked for also in the low-water levels. By as much as the high-water channel capacity is reduced the flood line will rise from its immediate lowering back toward its original level, but at the same time the low-water level will probably be rising, in a much more marked degree, toward its final limits. But what either of these limits might be in any case and to what extent the range from high to low water may be ultimately reduced by any given reduction of flood excess are of course as yet unanswered questions.

So much for the changes in regimen, but before leaving the Lower Mississippi data its remarkable system of swamp reservoirs has yet to be considered. It is evident, with any of these swamp fronts open to outflow, that the total outflow in different floods might be very different, and this also even where the floods reached the same extremes, for while the rate of outflow at any point may be a matter of stage alone, the total outflow there is a matter also of the duration of that stage. It is thus only in the sequence of stage and discharge from point to point, shown on Pl. II, that the difference between free and restrained outflow can be noted; and while certainly the restraint les-

sens the total outflow, its degree does not show in such comparisons unless the floods compared happened to be of essentially the same form, which is hardly possible.

But though the different degrees of flood restraint can not be accurately expressed in any system of summations whatever, a high degree of restraint would, of course be very apparent, while the total volumes of free outflow and inflow, show something of the great reservoir capacity of these swamp basins and give the storage equivalents of their effect on the floods. It is thus altogether desirable to have these summations, and from the data on Pl. II they are very easily made up. The only difficulty is that their values are at best necessarily but very rough approximations. Were there no local drainage, the difference between the annual discharge at Cairo and Memphis would, of course, give the total outflow; but in such a value the local drainage through the year is not insignificant and can not be ignored, and even if it could, small percentages of error in the large values of the annual discharges might make very material errors in their differences, from which this outflow is obtained.

To avoid in a great measure both of these sources of error, the floods have also been summed from the 1,000 level up, or all above the general bankful stage; and in these shorter periods and smaller quantities it is thought that the differences give more nearly correct values of the outflow and inflow totals. It is true that this fails in those cases where the inflow falls between crests, while in all cases the summations do not include the considerable inflow that drains back after the river has fallen within banks. This, however, is to some extent offset by the local drainage through the flood period, but probably to a greater extent even by a characteristic of the planes of flow here. Through all the filling up between crests and backwater drainage these planes are in general abnormally high; and while the average planes may possibly undervalue the total outflow, as also the extremes of inflow on the crests of the swamp wave, they also may, and probably do, at the same time overvalue the total inflow, in the fact that the stage is thus swelled by this back drainage more than is warranted by its actual additions to the discharge.

But while neither of these methods is very satisfactory, the summations of annual volumes and the volumes above the bank level, or flood excesses, are in themselves worth knowing, and their differences in the last case are probably as close an approximation as can be made to the totals of outflow and inflow. They are therefore given in the following table for all the floods from Cairo to Vicksburg, with the differences between the flood excesses from point to point down, in which, of course, the minus difference indicates an outflow and the plus an inflow between the respective gauges.

In these summations it is convenient to take for the unit of volume a discharge of 100,000 cubic feet per second for one day, or a square mile covered to the depth of 310 feet. With this unit, in making up the total volumes from the data on Plate II, it is only necessary to scale the average width in days of each of the discharge-scale divisions and sum these from zero up for the total annual discharge and from 1,000 up for the flood excesses. This last has for each flood the definite limits of stage, but the total annual discharge is arbitrarily taken from the low-water period of one year to the low water following, or from October 1 to October 1, except in the case of a leap year, where it is still taken through only 365 days from October 1 to September 30.

Total annual discharges—Flood excesses above the general bank-full stage—Differences giving approximate totals, minus of outflow, plus of inflow.

	1881–82.			1882–83.			1883–84.		
	Total annual discharge.	Flood excess.		Total annual discharge.	Flood excess.		Total annual discharge.	Flood excess.	
		Total.	Differences.		Total.	Differences.		Total.	Differences.
Cairo	2,936	318		2,049	168		2,227	226	
			—141			— 87			—135
Memphis	2,845	177		2,002	81		2,108	90	
			+ 97			+ 44			+168
Helena	3,007	274		2,156	125		2,293	198	
			+ 45			+ 58			+ 29
Mouth White River	3,197	319		2,464	183		2,598	227	
			—259			—163			—161
Lake Providence	2,944	60		2,321	20		2,417	66	
			+272			+118			+227
Vicksburg	3,234	332		2,468	138		2,803	293	

	1891–92.			1892–93.			1896–97.		
	Total annual discharge.	Flood excess.		Total annual discharge.	Flood excess.		Total annual discharge.	Flood excess.	
		Total.	Differences.		Total.	Differences.		Total.	Differences.
Cairo	2,054	170		1,707	159		2,053	274	
			—40			—48			— 88
Memphis	2,098	130		1,810	111		1,945	186	
			+58			+47			+ 83
Helena	2,226	188		1,928	158		2,095	269	
			+82			+60			+ 3
Mouth White River	2,447	270		2,193	218		2,255	272	
			—17			—58			— 13
Lake Providence	2,477	253		2,140	160		2,228	259	
			+93			+68			+115
Vicksburg	2,569	346		2,249	228		2,375	374	

With the above values of outflow and inflow all kinds of comparisons can be made. For instance, in 1882 from Cairo to Helena, the 141 outflow is a discharge of 100,000 cubic feet per second for 141 days; or between the beginning of outflow and its 500 extreme it may be taken as an average, say, of 300, or rather more than the average Missouri River flood for 47 days; while between the outflow of 141 and the inflow of 97 there is the loss into the upper Yazoo of 44, or this same Missouri flood for about 15 days. Again, the 141 is the storage equivalent which in that year cut down the flood from its extreme of 1,700 at Cairo to about 1,200 at Memphis, and in square miles 10 feet deep is $\frac{141 \times 310}{10} = 4{,}371$; or about two-thirds of the 6,706 square miles of overflowed area in the St. Francis Basin.

It is here in the relation of the total outflows to the areas of these swamp basins that their immense reservoir capacity is best seen; not only they can and do reduce the floods, but the St. Francis Basin in cutting down the great flood of 1882 between Cairo and Memphis only takes off what would cover its total area to an average depth of about 7 feet. The reservoir question for the Lower Mississippi is not, therefore, the insignificant and uncertain effects of head-water reservoirs, but wholly the question of how and to what extent the reservoir capacity of these swamps may be utilized.

Certainly they are of little value as they are, for while they reduce the flood stage to some extent, they also prolong it; but all this does not rise from their lack of capacity to take off enough water, but from their inability to hold it until after the flood period has passed. For instance, in the St. Francis Basin, with something like 120 feet fall for its natural

drainage from Cairo to Helena, the outflow along its front gathers into a second flood and comes back at Helena, retarded it is true, but rarely retarded enough even to fall between crests, while in most cases it comes back upon the same general level from which it was drawn off. If, however, its natural drainage were barred by a system of cross levees, making of it a series of shallow reservoirs with their outflows under control, not only could the whole effect of the natural cutting down of the 1882 flood have been retained, but by artificially enlarging the outflow a very decidedly greater reduction could have been made.

Just what capacity could be given to such a chain of reservoirs, or what the locations and dimensions of the cross levees forming them, is of course entirely beyond the scope of this study; but it does not seem improbable that the total fall of 120 feet might be so divided as to store an average depth of 20 feet; and this, over an area of 4,000 square miles, is $\frac{4000 \times 20}{310} = 258$, in the place of 141, the actual outflow of 1882. That is, less than two-thirds of the St. Francis Basin so used would have cut the 1882 flood down to between 1,000 and 1,100 and would have taken off the total excess at Cairo of every other flood to 1897; where again the 274 summation is slightly in excess of its capacity and the reduction of 258 is a little above the 1,000 level, or almost exactly to the 40-foot stage at Cairo. While again the emptying of this 258 upon the low-water period would entirely obliterate it, and from there down the 15-foot stage would probably be as rare as the zero stage is at present.

True, such a system would in time certainly fill up; for with flood water averaging a sediment of 1 in 1,000, the deposit from a thousand annual fillings with water would equal the average volume withdrawn from the floods. But as in the course of centuries the upper divisions of such a system emerged above the reservoir level, its capacity might still be maintained by extending the system into the lower swamps. All this, however, is no question of the present, nor indeed does it promise to be one of the future; for if the dream of internal navigation is to be realized and Cairo is to be made a Gulf port, it is not at all improbable that it will come by some system of slack-water navigation up the swamps; in which case the interests of navigation would altogether outrun the storage requirements in the extension of this chain of lateral reservoirs down. But for the present the question is wholly confined to the upper basin; for could even the natural outflow into the St. Francis be held back, it is evident that the danger of an extreme flood below would be greatly reduced, while with this enlarged capacity withdrawn annually from the flood extremes and returned to the low-water period, the Lower Mississippi would certainly be altogether a different river.

Up to the St. Francis Basin, therefore, there has been no real conflict with the local interests that would reclaim the swamps or that demand immediate protection; but here the conflict begins, and to the engineer it is simply a question of the cost and its effects. The effects have been briefly noted, and even had they not been noted the data would speak for themselves; and with this the study must close, for the cost would require an extended study of its own, based on surveys that have not as yet been made. Though probably no work that man can ever do would so profoundly modify this whole lower river, it should not be assumed that even in this labyrinth of lakes and bayous a sufficient storage could be provided without sacrificing large local interests and without construction works that would certainly be difficult, and that altogether might not warrant the expense.

APPENDIX D.

RESOLUTION OF THE ROCK CREEK AND PINEY RESERVOIR AND DITCH COMPANY RELATIVE TO RELINQUISHMENT TO THE UNITED STATES OF ITS RIGHTS OF WAY OVER PINEY AND CLOUD PEAK RESERVOIR SITES.

OFFICE ROCK CREEK AND PINEY RESERVOIR AND DITCH COMPANY,
Buffalo, Wyo., September 25, 1897.

Whereas, the Rock Creek and Piney Reservoir and Ditch Company did on the 7th day of December, 1896, file and cause to be filed in the office of the Buffalo, Wyo., land office their map and application for a right of way under and by virtue of the act of Congress for the acquirement of rights of way over the public domain for ditches and reservoirs, etc., and which said application covered two certain reservoir sites, viz, the "Piney Reservoir," located in sections 23, 24, 25, and 26 in township 52 north of range 85 west of the sixth principal meridian, and also the "Cloud Peak Reservoir," located in sections 9, 16, and 17 in township 51 north of range 85 west of the sixth principal meridian, and all in Johnson County, State of Wyoming, and which said application was duly approved on the 16th day of July, 1897, by Hon. C. N. Bliss, Secretary of the Interior of the United States of America, and all as appears by the official plat thereof on file in the General Land Office, at Washington, D. C., and the local United States land office at Buffalo, Wyo., and

Whereas, a proposition—informal in its nature—has been made to said Rock Creek and Piney Reservoir and Ditch Company to relinquish its right of way for the purpose of allowing the Government of the United States to occupy said sites for experimental storage reservoir construction; now, therefore,

Be it resolved by the stockholders of the said company, That the board of trustees be, and they are hereby, authorized and directed to make, execute, acknowledge, and deliver all necessary conveyances and instruments for the purpose of releasing said rights of way and to carry into effect the desires of the Government of the United States touching the use and occupation of said reservoir sites, as granted and now held by this company.

I, William Bryant, president of the Rock Creek and Piney Reservoir and Ditch Company, do hereby certify that the above and foregoing is a full and correct copy of the proceedings of the stockholders' meeting of said company, called and held for the purpose of voting upon a proposition to release its rights of way for two certain reservoirs, above named, to the United States of America for the purpose of constructing thereon experimental storage reservoirs by the United States; that the same has been compared by me with the original records and is found on page 32 of Book A of the records of said corporation.

In witness whereof I have hereunto set my hand as president of said company, and caused these presents to be attested by Isaac N. Lane, secretary of said company, at Buffalo, Wyo., this 25th day of September, 1897.

WILLIAM BRYANT, *President.*

Attest:
[SEAL.] ISAAC N. LANE, *Secretary.*

The foregoing instrument was executed by the parties in question without request from myself other than a simple inquiry as to whether they would be willing to relinquish their rights in case the Government should undertake to improve the sites. Nothing was said of "experimental" reservoirs. The instrument is presented herewith simply as evidence of the readiness of the parties in possession to transfer their right and title to the sites in question to the Government.

HIRAM M. CHITTENDEN,
Captain of Engineers.

APPENDIX E.

LETTER FROM MR. H. A. SUMNER, EX-STATE ENGINEER OF COLORADO, ON CONSTRUCTION OF RESERVOIRS BY STATE OF COLORADO.

DENVER, COLO., *October 16, 1897.*

DEAR SIR: Your letter of September 28 was received, but absence from the city has prevented my answering sooner.

Regarding the State reservoirs, I will say that while water stored under State supervision and control might be of great benefit to the consumers below and could be made to work very beneficially to the citizens of the State, such improvements should be taken up by the State engineer's office and exhaustive examinations made as to

supply and wants of consumers, and after the proper estimates have been made the legislature should be asked to set aside the money to construct the same.

Instead of this plan having been followed, however, a few years ago it became a fad with the members of the legislature to inaugurate an era of State reservoir construction in connection with wagon roads and bridges in the several counties, such improvements being paid for from what is known as the "Internal improvement fund of the State.

The legislative bills would be passed, setting aside a stated sum of money and locating a reservoir in or near a certain stream, and all the State engineer had to do was to go out and endeavor to find the proper storage facilities which would not cost more than the sum named in the legislative bill.

State wagon roads and bridges have been built on the same basis.

This makes unsatisfactory work, and on the whole has impeded what might have been the commencement of State aid to assist the irrigation interests, if it had been properly inaugurated and carried out.

For these reasons I have always been afraid that Government aid would be withheld, because so far the State has not succeeded in benefiting to any great extent the people of the State in its efforts.

To give a brief history of the reservoirs built by the State, I will take them in the order they were built.

APISHAPA RESERVOIR.

Situated in Las Animas County, in the Metote Canyon, between the Trojilla and Apishapa creeks. Dam of earth.

The Metote Canyon has a limited catchment area, and the reservoir is filled by a ditch about 2 miles in length from the Trojilla Creek, which heads near the Spanish Peaks and has a watershed of about 30 square miles.

The reservoir was completed in 1892, but has been of very little use to anyone, as the entire flow of Trojilla Creek is appropriated by farmers below and only the winter and flood waters can be stored.

The reservoir cost $14,771.80. Capacity, 20,000,000 cubic feet, or 459.11 acre-feet, which is, for one filling of reservoir, $32.18 per acre.

MONUMENT RESERVOIR.

Situated in El Paso County, on Monument Creek, immediately west of Monument Station on the Denver and Rio Grande Railroad.

It has a catchment area of about 22 square miles, and the dam, which is of earth, is constructed across the stream, with spillways on each side.

The flood waters enable it to be filled at least once a year and often twice. The water has been turned out in times of need to those needing it below, and on the whole this reservoir has been of some use to the farmers. Completed in 1894.

The cost was $33,121.53. Capacity, 37,289,400 cubic feet, or 856.05 acre-feet, equivalent to $38.69 per acre for one filling of reservoir.

HARDSCRABBLE RESERVOIR.

Situated in Custer County, on a small ravine near Hardscrabble Creek, with a ditch from the latter creek to fill it.

Of very little use, as the creek which fills it is nearly dry in summer and the flood waters are its only source of supply. It is an earthen dam. Completed in 1894. Cost $9,997.31. Capacity, 4,453,600 cubic feet, or 102.24 acre-feet, equivalent to $97.78 per acre for one filling of reservoir.

BOSS LAKE RESERVOIR.

Situated in Chaffee County, on the head waters of the South Arkansas River, about 4 miles north of Monarch and near the Main Range.

The catchment area is only about 4 square miles, and the dependence is on winter snows, which are to be held back in the spring months.

Owing to the reported unsafe condition of dam, which is of earth, the reservoir has never been filled, but the benefit from it when in use can never be much.

It was completed in 1894 and cost $14,654.24. Capacity, 8,940,661 cubic feet, or 205.25 acre-feet, which is $71.39 per acre for one filling of reservoir.

SAGUACHE RESERVOIR.

Situated near Saguache, Saguache County, in a ravine near the Saguache River, and is filled from the latter stream by a ditch. The present supply of the stream being appropriated, but very little water is available for this reservoir and only in the winter or early spring months. Dam constructed of earth.

It was completed in 1894 and cost $30,000. Capacity, 41,556,240 cubic feet, or 954 acre-feet, which is $31.45 per acre for one filling of the reservoir.

Yours, truly,

H. A. SUMNER.

H. M. CHITTENDEN,
Captain of Engineers, U. S. A.

APPENDIX F.

LETTER OF MR. ELWOOD MEAD, STATE ENGINEER OF WYOMING, ON PERCENTAGE OF STREAM FLOW REQUIRED TO BE STORED IN THE ARID REGIONS.

CHEYENNE, WYO., *October 27, 1897.*

DEAR CAPTAIN: Replying to your inquiry about the percentage of the total flow of a stream which has to be stored in order that all of its flow may be used in irrigation, would say:

There is a wide variation in different parts of the arid region because both the flood season and the time when water is needed differs greatly in different sections. In order that a stream might be entirely used without storage it would be necessary for the variations in use to correspond to the variations in discharge, and the farther they are apart the greater need of regulating the natural flow through this means.

If you will examine the diagrams, which show the discharge of streams measured, in the several engineers' reports from this State, you will observe that almost without exception the discharge of all these streams, in the thirty days from May 15 to June 15, is greater than the total flow of the stream for the remainder of the year, and in order for the stream to be used without the aid of storage the irrigation of crops must be concentrated in the same ratio within this period.

With this letter I also send you a table showing the discharge of streams in Wyoming during the irrigation season of 1897. In this you will notice that with nearly all these streams the number of acre-feet in the discharge for May is greater than for any subsequent months and almost equal to the combined discharge for the remainder of the irrigation season—in some cases entirely so.

It will also be noticed that on Green River the acre-feet discharged in May is three times that of July; on Blacks Fork the May discharge is ten times that of July; on the North Platte, seven times; on the Laramie at Uva, three times, and at Woods, six times, and on Clear Creek, approximately four times.

The use of water in irrigation varies somewhat in different years, but it is the unanimous belief of the members of the board of control that the greatest use of water occurs in June and July, and that the requirements of these two months are about equal; that in ordinary seasons the use of water in May is merely nominal, the rainfall of that month being often entirely sufficient. It is the exception rather than the rule for any water whatever to be used in April. Alfalfa, root crops, and orchards require irrigation in August and September, and the percentage of water required during these months generally increases with the length of settlement of a particular section.

Remembering now that as much water is required in July as in June, and that the requirements of both these months are far in excess of May, we can understand how greatly the natural flow of the streams measured will have to be modified before all the water can be used.

The limits of this letter will not permit a discussion of each of these streams, nor is this necessary; a single one will illustrate this matter as fully as all of them. Let us take the North Platte River. The use of water above the point where measured is so small that it practically represents the normal flow of this stream. As June and July are the months of maximum requirement and as their needs are about equal, the July discharge of 102,000 acre-feet will fix the limits of irrigation under normal conditions; but when this has been reached, there yet remains entirely unused the 253,000 acre-feet of April, more than 700,000 of May, and fully 400,000 of June. Unless this can be stored or in some way held back to augment the July discharge, three-fourths of the total discharge must run to waste. It will not be necessary, however, to store this volume in order to secure the maximum use. If the 700,000 acre-feet of the May discharge can be stored and added to the discharge of June and July, it gives a total for those two months of 1,300,000 acre-feet, or 650,000 acre-feet for each of the two months. The return waters from seepage from this use will be amply sufficient to meet the increased demands of August and September, so that it would be a close approximation to the truth to say that by storing 40 per cent of the discharge of this stream we can secure the complete use of its water. This ignores the April discharge, which, if included, would somewhat increase the percentage required to be stored. Storing 40 per cent of the stream's flow does far more than increase the reclaimed acreage by that per cent. It practically increases it in this case 600 per cent. Instead of having the reclaimed area fixed by the work which 102,000 acre-feet will perform, it is fixed by the land which 752,000 acre-feet will serve. I hope I have succeeded in making my meaning clear to you.

The storage of water, if generally undertaken, will remove one of the most perplexing problems connected with water rights and one of the most prolific sources of controversies. If we stop the taking out of ditches when the limit of the July flow has been reached, and with it the limit of possible complete irrigation, there still goes to waste the greater part of the discharge of the stream during the earlier months. People, seeing this, insist on building ditches to utilize it, and the result is that we have an abundance of water to begin the raising of crops and bitter controversies to prevent their destruction before maturity. Under these conditions "stored water," to use Mr. Nettleton's expression, can be compared to the water which puts out the burning house. While it would be worth comparatively little if it was used for the complete irrigation of crops, used as it will be its value must be measured by what it serves in the emergency which calls for its use.

An examination of the discharge of some of the other streams makes an even stronger case for reservoirs, and you will find by an examination of the several engineers' reports of this State that the discharges of 1897 are in no way an exception.

Some criticism may be made of the statement that the demands of July are as great as those of June and greater than of May. I have stated that this is the conclusion of the members of the board of control, based on their personal experience. The measurements which I made in 1889 of the water used at Wheatland confirmed this. You will see that no water whatever was used in May, that the July demands on oats were far greater than those of June, and that the only water used in the irrigation of potatoes was used in July.*

The measurements of the duty of water made by the agricultural department of the State University of Colorado showed that the irrigation season includes May, June, July, and August, but there is no record in their experiments of any water whatever being used in May, and the number of irrigations in July equal those in June. The tables do not permit of any accurate determination of the relative volumes used in either of these two months. In Bulletin No. 22, Duty of Water, issued by the Agricultural College of Colorado, it will be noticed that, while the irrigation of small grain required more water in June than in July, forage crops and root crops required a larger use of water during the latter month. It must be remembered, also, that in the measurements made there people used water when they had it, and that it was not the greater necessity of June but the greater June supply that led to the enlarged use during that month.

In Wyoming and Montana irrigation takes place at a later period than in Colorado, so that I am convinced that the conclusions of our board are substantially correct.

I regret that I have not time to go into this matter more in detail, but the meeting of the State board of control and the large amount of business which remains to be closed up as a result thereof makes it impossible. I am confident, however, that the statement that 40 per cent of the water of our streams must be stored if all is to be used is substantially correct, and that through such storage the acreage which can be watered can be increased from three to four times that which can be profitably irrigated by means of the natural flow alone.

Sincerely, yours,

ELWOOD MEAD.

Capt. H. M. CHITTENDEN.

Table showing the discharge of streams in Wyoming during the irrigation season of 1897.

Name of stream.	Apr.	May.	June.	July.	Aug.	Sept.
Green River:						
Mean discharge...cubic feet per second..	2,000	9,121	7,506	2,884	1,692	854
Total flow .....acre-feet..	118,764	559,849	446,013	177,048	103,880	50,738
Blacks Fork:						
Mean discharge...cubic feet per second..	.....	3,972	1,302	332	145	172
Total flow .....acre-feet..	.....	243,782	77,374	20,452	8,780	7,231
North Platte:						
Mean discharge...cubic feet per second..	4,451	14,003	8,918	1,778	869	537
Total flow .....acre-feet..	253,156	790,670	495,363	102,369	47,426	31,360
Laramie-Uva:						
Mean discharge...cubic feet per second..	688	1,241	1,082	41	118	12
Total flow .....acre-feet..	40,729	76,208	64,273	2,527	7,245	699
Laramie-Woods:						
Mean discharge...cubic feet per second..	145	1,922	1,542	316	113	579
Total flow .....acre feet..	8,639	117,968	91,634	19,366	6,944	3,437
Clear Creek:						
Mean discharge...cubic feet per second..	.....	342	279	89	55	.....
Total flow .....acre-feet..	.....	20,295	16,602	5,503	3,332	.....

*State engineer's report 1889, in set, page 33.

LETTER OF MR. F. J. MILLS, STATE ENGINEER OF IDAHO, ON PERCENTAGE OF STREAM FLOW REQUIRED TO BE STORED IN THE ARID REGIONS.

STATE ENGINEER'S OFFICE,
Boise, Idaho, October 29, 1897.

DEAR SIR: I beg to acknowledge the receipt of your favor of the 25th instant, and am pleased to comply with your request in regard to storage of water, as fully as I am able. Perhaps we can arrive at a solution of the question you ask by considering a specific case better than in any other way. On account of the reasonable completeness of the record, I will take the Boise River as an example, hoping that from a statement of the conditions on this stream you may reach an approximate answer to your inquiry.

In the report [First Biennial Report of the State Engineer to the Governor of Idaho] of this office, page 15, we find that the total flow of the Boise River during 1895 (a low-water year) was, in round numbers, 1,500,000 acre-feet. The present duty of 1 acre-foot of water from the Boise, somewhat discussed in report, page 60 et seq., we will assume to be the irrigation of one-fourth acre per year. Now, if the total flow of the Boise could be applied to irrigation, it would be sufficient to irrigate, on that basis, 375,000 acres of land, neglecting evaporation from reservoirs, etc., for the present. This is what it would do if the water were all conserved and used, assuming that we have absolute control of the whole run-off.

Now, what will it do without reservoirs, simply using such part of the flow as may be available when needed?

The time when the water has to be applied for irrigation (incompletely discussed on page 64 of report) may be roughly stated as follows:

	Percentage of whole amount.
May	15
June	30
July	30
August	15
September	10
Total	100

This would be, per acre, 0.6 acre-feet in May, 1.2 acre-feet in June, same in July, 0.6 acre-feet in August, and 0.4 acre-feet in September; total, 4 acre-feet per acre. Turn now to page 15 of the report, and we find that the possibilities for irrigation by the waters of this stream will be limited by its average August flow of 1,039 cubic feet per second, or about 65,000 acre-feet for the month. We need 0.6 acre-feet per acre during the month, consequently the area that can be irrigated from this river would be about 108,000 acres, it being limited by the August flow, although there is a large surplus during the other irrigating months.

Let us assume that the Boise River will irrigate 108,000 acres of land without reservoirs, how much storage of water will we have to have to make it irrigate 216,000 acres? From the table of flow we find that the natural flow in May is 6,214 second-feet, or approximately 375,000 acre-feet. We would consequently not have to draw upon the stored water in May. The June flow is 3,746 second-feet, equals 225,000 acre-feet. We need $216,000 \times 1.2$, equals 259,000 acre-feet in June. Consequently we would draw 34,000 acre-feet from the reservoirs in June. The July flow is 2,483 second-feet, equals 150,000 acre-feet. We need $216,000 \times 1.2$, equals 259,000 acre-feet in July. Consequently we would need to draw 109,000 acre-feet in July. The August flow of 1,039 second-feet, equals 65,000 acre-feet, is just enough for 108,000 acres (this being the limiting flow). We need $216,000 \times 0.6$, equals 130,000 acre-feet in August. Hence we would have to draw 65,000 acre-feet from the reservoirs in August. The September flow is 970 second-feet, or about 60,000 acre-feet. We need $216,000 \times 0.4$, equals 86,000 acre-feet in September. We would, therefore, have to draw 26,000 acre-feet from the reservoir. We would, therefore, use 34,000 plus 109,000 plus 65,000 plus 26,000, equals 234,000 acre-feet from the reservoirs during the season in order to do an amount of irrigation equal to that done by 432,000 acre-feet taken directly from the stream. Thus we see that while we can use only 432,000 acre-feet of water from the ordinary flow of the river, by storing 234,000 acre-feet we can use 864,000 acre-feet of the flow of the same river at exactly the same periods and to equal advantage.

Let us now see what we would have to store (on basis of 1895 flow) to utilize *all* the run-off of the river, assuming that there is land to use it upon (which is not true in this particular case). The total capacity of river is, we will assume, the irrigation of 375,000 acres. The May flow is 6,214 second-feet, equals 375,000 acre-feet; so we would not draw upon the storage in May. We need in June $375,000 \times 1.2$, equals 450,000 acre-feet. The June flow equals 225,000 acre-feet. We would have to draw 225,000 acre-feet in June. In the same way we find we would consequently draw 300,000 acre-feet in July, 160,000 acre-feet in August, and 90,000 acre-feet in September, equals 775,000 acre-feet of storage needed in order to utilize the entire flow of the stream.

We can use 28.8 per cent of the river without storage. By storing 15 per cent of the total annual flow we would be able to utilize 57.7 per cent of the total flow. By storing 51 per cent we would be able to use the total annual flow.

The season of 1895 was one of much more nearly uniform flow throughout the year than usual. During most years (see table of flow for 1896) by storage of a much smaller quantity the same available water could be secured.

These calculations will, of course, vary for different streams.

I have contented myself with approximate calculations in this letter, although near enough for practical purposes. If you desire to take up several streams in order to get an average, by taking the records of their flow in connection with the table on page 64 of my report, you will not go far wrong for Idaho, Utah, Colorado, Montana, and Wyoming anyway, probably not very far wrong for any locality where general irrigation farming is the rule. I will say, however, that my later investigations tend to rather increase the proportion of water used in June and July, so that I think 15 per cent for May, 30 per cent each for June and July, 15 per cent for August, and 10 per cent for September are not far off for this country. Of course, a little water is sometimes used in April and October, but it is ordinarily a very small proportion of the whole, and I have in this table included it in the estimates for May and September.

Perhaps we had better calculate the condition on another stream for the same year. Let us take the Weiser River. This stream fluctuates more than the Boise, in fact, more than most rivers of this State.

The total flow for 1895 was 500,000 acre-feet; for 1896 it was 1,400,000 acre-feet. We may assume that 3 acre-feet of water are used annually on each acre irrigated from the Weiser below the point of measurement. Hence the total 1895 flow, if all could have been used, would have irrigated about 166,000 acres. From an inspection of table of flow, page 10 of report, we see that the August flow is the limiting flow of this stream. The flow in August is 79 second-feet, or 2,449 acre-feet. We need 15 per cent of 3 feet, or 0.45 acre-feet, per acre in August. Two thousand four hundred and forty-nine divided by 0.45 equals 5,450 acres as the maximum area which can be irrigated on this basis from the ordinary flow of the river. Let us see how much storage it would take to double the irrigating efficiency of this river. By a process similar to that used on the Boise River we find that a storage of only 2,449 acre-feet will accomplish this purpose.

To utilize all the flow, or to irrigate 166,000 acres from this river, no storage will be needed for May. The June flow is 854 second-feet, or 51,000 acre-feet. We need $166,000 \times 0.9$, equals 149,000 acre-feet; hence we would need 98,000 acre-feet from storage in June. The July flow is 312 second-feet, equals 19,000 acre-feet; hence we would draw 147,000 acre-feet from storage in July. The flow in August is 79 second-feet, or 2,450 acre-feet. We need $166,000 \times 0.45$, equals 74,500 acre-feet; hence we would have to draw 72,000 acre-feet from storage in August. The September flow is 140 second-feet, or 8,400 acre-feet. We need $166,000 \times 0.3$, equals 49,800 acre-feet; hence we would draw 41,000 from storage. We therefore find that 98,000 plus 147,000 plus 72,000 plus 41,000, equals 358,000 acre-feet, would have to be stored in order to utilize the full flow of the stream.

Hence we see that only about 3½ per cent of the Weiser is available for irrigation without storage. By storing one-half of 1 per cent of the total flow we double the irrigating efficiency of the stream. We would have to store 71 per cent of the total flow in order to render it all available for irrigation.

From the results of the above calculations on two streams selected almost at random we see that no general average can be made covering the point under consideration. If we should take the year 1896 instead of 1895 for calculations on these same streams, our resulting percentages would be very different. Some streams in this State which flow annually large quantities of water are not available without storage at all, on account of being completely dry during part of the time when water must be had, but which flow during a part of the irrigation season, while some streams flow only during periods when no irrigation is done, thus necessitating storage of full amount used for irrigation. Some streams rise from large springs and have practically a uniform flow during the entire year. Uniformly flowing streams, you will note, would have to have some 70 per cent of their total annual flow stored in order to render the whole flow available. It will very rarely, if ever, occur that the total flow of a stream can be rendered available for irrigation without the storage of more than 50 per cent of its total annual flow. Probably very few streams will be available for irrigation without storage to a greater extent than 25 or 30 per cent of their total flow. The streams in this part of the country could have their irrigating efficiency very greatly increased by storage of a comparatively small quantity of water. In other words, by storing enough water to irrigate by itself, say, 1,000 acres, we may often increase the irrigating efficiency of the stream by 2,000, 3,000, 4,000, or even as high in some cases as 5,000 acres, by reason of the fact that the stored water may only have to be drawn upon during a very short part of the irrigating season.

I have written this very hastily, both on account of being very busy and in order

to get it to you at once, as you request. I have not attempted to be exact in the calculations, only exact enough for the purpose in view. I hope, however, that you will find in it and in the report sufficient hints to enable you to get at the information you may desire in regard to any particular stream. You can get tables of the annual flows of very many streams in Bulletin No. 140, United States Geological Survey, 1896, if you desire to go into the subject in detail.

The percentages of water used during the different months are only given as approximations. I have perhaps estimated the August necessity a little too small. Of course, if you desire more exactness, the estimates of the percentages necessary should be made for, say, each week, and the flow of the stream taken for such period also, rather than by months. But the calculations herein are intended only as approximations, as it is a matter in regard to which only an approximation can be had anyway.

I hope to get a copy of your report when it is made public.

Yours, very truly,

F. J. MILLS, *State Engineer, Idaho.*

Capt. H. M. CHITTENDEN,
Engineer Corps, U. S. A.

APPENDIX G.

TABLE OF WATERSHEDS.

[To accompany map of principal drainage basins of the arid section of the United States. Serial numbers refer to map.]

The areas were measured by means of a planimeter, from the latest Land Office map of the United States. They make no pretension to minute accuracy, but are rather designed to convey a general idea of the relation of the various watersheds to each other and to the total area of the arid region.

I.

MISSOURI RIVER BASIN.

[Above Kansas City.]

			Square miles.
1. Jefferson River			10,000
2. Madison River			2,591
3. Gallatin River			1,992
4. Sun River			2,469
5. Marias and Teton rivers			10,263
6. Musselshell River			9,609
7. Milk River			24,635
8. Poplar River			3,429
9. Muddy Creek			3,124
10. Yellowstone River			70,102
11. Yellowstone Lake		853	
12. Clarks Fork		2,894	
13. Pryors Creek		1,080	
14. Bighorn River		22,379	
15. Stinking Water River	2,783		
16. Grey Bull River	1,629		
17. Owl Creek	951		
18. Wind River	2,317		
19. Popo Agie River	2,012		
20. Little Bighorn River	1,255		
21. No Wood River	1,869		
22. Bad Water Creek	2,119		
Local Bighorn drainage	7,444		
Total	22,379		
23. Rosebud River		1,612	
24. Tongue River		5,266	
25. Powder River		13,579	
26. Little Powder River	2,187		
27. Clear Creek	1,154		
28. Crazy Woman River	1,140		
Local Powder River drainage	9,098		
Total	13,579		
Local Yellowstone River drainage			22,439
Total			70,102

	Square miles.
29. Little Missouri River	9,369
30. Knife River	2,515
31. Heart River	3,496
32. Cannon Ball River	4,545
33. Grand River	5,109
34. Moreau River	6,461
35. Cheyenne River	24,908
36. Belle Fourche or North Fork — 7,624	
37. South Fork — 13,421	
Local Cheyenne drainage — 3,863	
Total — 24,908	
38. Bad River	3,355
39. White River	10,435
40. James or Dakota River	20,265
41. Niobrara River	11,879
Local Missouri River drainage above Sioux City	82,911
Total Missouri River Watershed above Sioux City	323,462
42. Platte River	88,150
43. North Platte River — 33,043	
44. North Platte above Sweetwater — 8,289	
45. Sweetwater River — 3,064	
46. Laramie River — 4,855	
Local North Platte drainage — 16,835	
Total — 33,043	
47. South Platte River — 23,744	
48. South Fork — 2,049	
49. North Fork — 628	
50. Big Thompson River — 997	
51. Cache a la Poudre River — 1,740	
52. Lodge Pole — 2,566	
Local South Platte drainage — 15,764	
Total — 23,744	
53. Loup River — 16,429	
54. Elkhorn River — 6,609	
Local Platte drainage — 8,325	
Total — 88,150	
55. Kansas River	57,998
56. Big Blue River — 9,450	
57. Republican River — 23,776	
58. Solomon River — 6,590	
59. Saline River — 3,230	
60. Smoky Hill River — 8,085	
Local Kansas River drainage — 6,867	
Total — 57,998	
Local Missouri River drainage from Sioux City to Kansas City	22,152
Total Missouri River watershed above Kansas City	491,762

II.

ARKANSAS RIVER BASIN.

61. Neosho and Verdigris rivers and Caney Creek	21,155
62. Cimarron River	16,651
63. Canadian River	47,258
Local Arkansas River drainage to mouth Canadian River	60,733
Total Arkansas watershed from source to mouth Canadian	145,797

III.

RED RIVER BASIN.

64. Red River above mouth Washita River, including Washita	42,254

IV.

65. Pecos River, New Mexico	32,922

V.

		Square miles.
66. Rio Grande River above El Paso, Tex		42,162

VI.

COLORADO RIVER BASIN.

67. Green River		49,104
68. Grand River		25,365
69. Gunnison River	8,289	
70. Dolores River	4,855	
Local Grand River drainage	12,221	
Total	25,365	
71. San Juan River		19,014
72. Little Colorado River		22,632
73. Virgin River		8,713
74. Gila River		62,949
Local Colorado drainage to Yuma		60,254
Total Colorado River watershed		248,031

VII.

SALT LAKE BASIN.

75. Bear River	7,624
76. Weber and Ogden rivers	2,077
77. Utah Lake	4,495
78. Sevier River and Lake	9,386
Local Salt Lake drainage	8,353
Total	31,935

VIII.

79. Humboldt River Basin	30,100

IX.

DESERT BASINS.

80. From Great Salt Lake to southern boundary of California, including Salt Lake and Ralston deserts	107,815

X.

LAKES OR SINKS WITHOUT OUTLETS.

81. Owens, Mono, Tahoe, Walker, Pyramid, Winnemucca, Honey, Eagle, Warner, Abert, and Summer lakes	44,802

XI.

COLUMBIA RIVER BASIN.

82. Columbia River in United States, omitting Snake River		117,110
83. Snake River		103,237
84. Palouse River	2,991	
85. Clearwater River	8,492	
86. Salmon River	12,959	
87. Weiser River	1,611	
88. Payette River	3,600	
89. Boise River	3,384	
90. Malade River	2,179	
91. Henrys Fork and Teton River	3,249	
92. South Fork Snake River	5,797	
93. Owyhee River	10,277	
94. Malheur River	12,737	
95. Grand Ronde River	4,061	
Local Snake River drainage	31,909	
Total	103,237	
Total Columbia River watershed in the United States		220,347

XII.

PACIFIC COAST DRAINAGE.

[Omitting Columbia River.]

	Square miles
96. Sacramento River	32,000
97. San Joaquin	30,478
98. Klamath River	16,632
Local Pacific drainage	77,015
Total	156,125

SUMMARY.

I. Missouri River Basin above Kansas City	491,762
II. Arkansas River Basin above mouth of Canadian River	145,797
III. Red River Basin above mouth of Washita River	42,254
IV. Pecos River in New Mexico	32,922
V. Rio Grande River above El Paso, Tex	42,162
VI. Colorado River Basin in the United States	248,031
VII. Salt Lake Basin	31,935
VIII. Humboldt River Basin	30,100
IX. Desert Basins	107,815
X. Lakes, sinks, etc	44,802
XI. Columbia River in the United States	220,347
XII. Pacific coast drainage, besides Columbia River	156,125
Entire area of that section of the United States between Pacific Ocean and points on Atlantic flowing streams designated in above list	1,594,052
Omitting Pacific coast streams and Columbia drainage, except Snake River	273,233
Gives	1,320,817

INDEX TO FOREGOING REPORT OF CAPT. HIRAM M. CHITTENDEN, CORPS OF ENGINEERS, UPON EXAMINATION OF RESERVOIR SITES IN WYOMING AND COLORADO.

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APPENDIX Q Q.

SURVEY OF SHAG ROCKS, ARCH ROCK, BLOSSOM ROCK, TWO MISSION ROCKS, AND ANITA ROCK, SAN FRANCISCO HARBOR, CALIFORNIA.

REPORT OF COL. CHAS. R. SUTER, CORPS OF ENGINEERS.

[Printed in House Doc. No. 105, Fifty-fifth Congress, second session.]

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 1, 1897.

SIR: I have the honor to submit the accompanying copy of report of October 13, 1897, with map,* by Col. Charles R. Suter, Corps of Engineers, of the results of surveys of Shag Rocks, Arch Rock, Blossom Rock, Two Mission Rocks, and Anita Rock, all in San Francisco Harbor, California.

These surveys were made to comply with requirements of the river and harbor act of June 3, 1896, and the estimated cost of removal is as follows:

Anita Rock, to depth of 30 feet below mean low water	$253,080
Arch Rock, to depth of 30 feet below mean low water	503,040
Shag Rocks:	
No. 1, to depth of 30 feet below mean low water	76,000
No. 2, to depth of 30 feet below mean low water	59,580
Blossom Rock, to depth of 30 feet below mean low water	92,600
Two Mission Rocks:	
Mission Bay Rock, to depth of 26 feet below mean low water	112,000
Sonoma Rock, to depth of 25 feet below mean low water	10,000
Total	1,106,300

It will be observed that Colonel Suter states that—

If this work, or any part of it, should be undertaken, it would undoubtedly be necessary to make contracts for the entire completion of each rock by itself. The amount to be appropriated at any one time should therefore be the entire estimate for at least one of these rocks.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

*Not reprinted. Printed in House Doc. No. 105, Fifty-fifth Congress, second session.

REPORT OF COL. CHAS. R. SUTER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., October 13, 1897.

GENERAL: I have the honor to submit the following report on the survey of certain rocks in San Francisco Harbor, made in accordance with the provisions of the river and harbor act of June 3, 1896, and your instructions of September 5, 1896. Owing to the great exposure of the site of several of these rocks, the labor of making the surveys has been considerable, as only certain stages of the tide and favorable weather were available for the work. The field work has been in charge of Assistant Otto von Geldern; the office work has been done by Assistants von Geldern and Le Conte.

By referring to plate 1 of appended drawings, the relative position of these rocks to each other and to the usual channels of navigation may be noted. Anita Rock is about a mile inside of Fort Point, and just off the shore of the Presidio Reservation. Arch and Shag rocks lie between Alcatraz Island and Point Cavallo; Blossom Rock is between Alcatraz and Yerba Buena islands, while the Two Mission Rocks, Sonoma and Mission Bay, lie near the wharves of the city off Mission Bay.

In the estimates which follow, the quantities of rock to be removed are based on a proposed depth over the rocks of 30 feet at mean low water, this being the least which it is thought would safely meet the present and prospective needs of commerce. In the case of the Two Mission Rocks a less depth has been used, for reasons stated. The estimated cost of $20 per yard for removal may seem high; but in view of the exposed position of most of these rocks, which would render such work both difficult and tedious, I do not think it safe to make the estimate any less.

ANITA ROCK.

(Plate 2.)*

This rock is situated in a bight of the shore line, about a mile east of Fort Point and some 300 yards from the shore of the Presidio Reservation. It is awash at low water, and is marked by an iron spindle beacon and a buoy on the harbor side. It is entirely out of the usual track of vessels, which, however, occasionally get onto it, as is evidenced by the fact that the iron spindle has been several times knocked down. The recent survey shows the rock to consist of several isolated pinnacles. The whole area within the 30-foot contour measures 33,914 square feet. The rock is very hard, but its position is reasonably sheltered. The quantity of rock above the plane of 30 feet at mean low water is 12,654 cubic yards, which, at $20 per cubic yard, would cost for removal $253,080.

ARCH ROCK.

(Plate 3.)*

This is a bold, high rock, standing 30 feet above low water, and is very conspicuous. It is situated about two-thirds of a mile west of Alcatraz Island and half a mile north of the regular chart course followed in entering the harbor. The tide sets very strongly against it, and in foggy weather or with unfavorable winds vessels have been frequently wrecked or injured by coming in contact with it. The same, however, might be said of Alcatraz Island, which has been the scene of many disasters.

*Not printed.

The area of the rock inclosed by the 30-foot contour is fully 1.6 acres, and from its exposed situation the work of removal would probably be very difficult. The volume of rock above the plane of 30 feet below mean low water is 25,152 cubic yards, of which 1,025 are above the low-water plane. The cost of removal at $20 per cubic yard is $503,040.

SHAG ROCKS.

(Plate 4.)*

There are two of these rocks, which are designated as 1 and 2. No. 2 was developed by the recent survey.

Shag Rock No. 1 lies in the track of the ferryboats plying between San Francisco and Sausalito. It is a small pinnacle rising 4 feet above high water and surrounded by deep water. It was surveyed by Colonel Mendell in 1875, and the recent survey only extended somewhat the area covered. The total quantity of rock to be removed down to a plane 30 feet below mean low water is 3,800 cubic yards, which, at $20 per cubic yard, would cost $76,000.

Shag Rock No. 2 was developed by the recent survey. It has an area twice as large as No. 1 and only 17 feet of water above it at mean low tide. It lies E. by S. ½ S. from No. 1, and is about 250 feet distant. If No. 1 is removed, it would be essential to remove No. 2, which would otherwise remain a dangerous hidden obstruction.

The total quantity of rock to be removed above the plane of 30-foot depth at mean low water is 2,979 cubic yards, which, at $20 per yard, would cost $59,580.

The combined cost of removing the two Shag Rocks would therefore be $135,580. The situation is much exposed, as in the case of Arch Rock.

BLOSSOM ROCK.

(Plate 5.)*

This rock has been a menace to navigation ever since the earliest history of the harbor. It was removed to a depth of 24 feet at mean low water in 1869 and 1870 by Major Williamson, of the Corps of Engineers. This depth was at that time supposed to be ample, but the increasing draft of vessels has again rendered it dangerous. At extreme low tides there is only a depth on it of 21 or 22 feet, and as it lies directly in the track of vessels bound down from Port Costa, several ships have struck it and been injured. In consequence, it is now buoyed and carefully avoided when practicable. To cut the rock down to a plane 30 feet below mean low water will require the removal of 4,630 cubic yards of rock, which, at $20 per cubic yard, will cost $92,600.

TWO MISSION ROCKS.

(Plates 6, 7, and 8.)*

These two rocks, named, respectively, Sonoma (pl. 7) and Mission Bay (pl. 6) rocks, lie not far apart and close to the city wharves, off Mission Bay. As they are right in the track of vessels and have only 13 feet depth on them at low water, they are very dangerous obstructions and have caused many accidents. Both are now buoyed. They are high points on an extensive rock ledge extending out into the harbor, and

* Not printed.

the great extent of this ledge and the comparatively shallow water over it preclude the removal of these rocks to more than the general level of the ledge in their vicinity at any reasonable cost. For this reason the estimates are based on the removal of Mission Bay Rock to 26 feet below mean low water and Sonoma Rock to a depth of 25 feet below the same plane.

By reference to plate 8, it will be seen that Sonoma Rock lies within the pier-head lines approved by the Secretary of War. Mission Bay Rock lies but slightly outside of this line, and by a slight shifting, shown on the plate, both rocks could be brought within the pier-head lines and the necessity of their removal obviated.

To remove Mission Bay Rock to a depth of 26 feet below mean low water, 5,600 cubic yards of rock, at $20 per yard, $112,000, and Sonoma Rock to a depth of 25 feet below mean low water, 500 cubic yards, at $20 per yard, $10,000, making for the two rocks $122,000.

Summary of estimates.

Anita Rock	$253,080
Arch Rock	503,040
Shag Rocks, Nos. 1 and 2	135,580
Blossom Rock	92,600
Two Mission Rocks	122,000
Total	1,106,300

If this work, or any part of it, should be undertaken, it would undoubtedly be necessary to make contracts for the entire completion of each rock by itself. The amount to be appropriated at any one time should therefore be the entire estimate for at least one of these rocks.

Very respectfully, your obedient servant,

CHAS. R. SUTER,
Colonel of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

APPENDIX R R.

IMPROVEMENT OF RIVERS AND HARBORS IN CALIFORNIA SOUTH OF SAN FRANCISCO.

REPORT OF MAJ. CHAS. E. L. B. DAVIS, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. San Diego Harbor, California.
2. Deep-water harbor at San Pedro Bay, California.
3. Wilmington Harbor, California.
4. San Luis Obispo Harbor, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 2, 1898.

GENERAL: I have the honor to transmit herewith my annual reports upon the works of river and harbor improvements under my charge for the fiscal year ending June 30, 1898.

Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

R R 1.

IMPROVEMENT OF SAN DIEGO HARBOR, CALIFORNIA.

No work was done at this harbor during the fiscal year ending June 30,1898, the contracts providing for the expenditure of the funds appropriated by the act of June 3, 1896, having been completed during the previous year.

The jetty has now been brought up to a high-tide level for a distance of 3,347 feet, and a foundation course of brush and stone laid 645 feet farther, or to a distance of 3,992 feet from shore. There has been some settlement, but on the whole the work stands well. There is now an available depth of 21 feet at mean low tide.

It was intended to make a complete survey last fall, covering the bar, the channel, and the middle ground, so as to note the changes effected

by the works, but it having been announced in the columns of the daily press that the United States Coast and Geodetic Survey was about to make a complete resurvey of this harbor, no survey was made by this office, in order to avoid useless duplication of work. A survey should be made before work is resumed.

The total amount expended to June 30, 1898, is $289,741.35.

Money statement.

July 1, 1897, balance unexpended	$2,784.90
June 30, 1898, amount expended during fiscal year	26.25
July 1, 1898, balance unexpended	2,758.65
Amount (estimated) required for completion of existing project	184,400.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	184,400.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for the work.

March 3, 1875	$80,000	August 18, 1894	$50,000
March 3, 1879	1,000	June 3, 1896	50,000
August 11, 1888	1,000		
September 19, 1890	60,500	Total	292,500
July 13, 1892	50,000		

Commercial statistics for the year the improvement began.

	Vessels.	Freight.
	No.	Tons.
Entered	201	24,800
Cleared	195	11,667

The vessels, including 109 steamers, had an aggregate tonnage of 122,311 tons.

Commercial statistics for the year ending December 31, 1897.

[Furnished by collector of customs at San Diego, Cal.]

	Incoming.	Outgoing.
Vessels:		
Steam	254	253
Sailing	170	169
Total	424	422
Tonnage	223,792	222,026
Draft, greatest ..... feet..	24	24
Merchandise, general ..... tons..	34,279	20,668
Coal ..... do..	44,614	.....
Lumber ..... feet..	19,185,000	.....

	Tons.
Total amount of freight entered and cleared in 1876	36,456
Total amount of freight entered and cleared in 1897	146,931
Increase	110,475

No new lines of transportation were established during the year.

R R 2.

DEEP-WATER HARBOR AT SAN PEDRO BAY, CALIFORNIA.

The Board of Engineers, provided for by the river and harbor act of June 3, 1898, having decided in favor of constructing the deep water harbor for commerce and of refuge at San Pedro Bay, California, bids were solicited by public advertisement and opened February 10, 1898. These bids, together with an abstract of the same, were forwarded February 12, 1898, but up to the close of the fiscal year ending June 30, 1898, no award of the contract has been made.

For the full report of the Board with its accompanying documents, see Senate Doc. No. 18, Fifty-fifth Congress, first session.

Money statement.

July 1, 1897, balance unexpended	*$14,144.66
Amount appropriated by sundry civil act approved July 1, 1898	400,000.00
July 1, 1898, balance unexpended	414,144.66
July 1, 1898, outstanding liabilities	177.27
July 1, 1898, balance available	413,967.38
Amount that can be profitably expended in fiscal year ending June 30, 1900 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	400,000.00

Abstract of bids for construction of breakwater at San Pedro, Cal., received in response to advertisement of December 10, 1897, and opened at San Francisco, Cal., at 12 m., February 10, 1898, by Maj. Chas. E. L. B. Davis, Corps of Engineers.

	Name and address of bidder.	Foundation course (136,020 tons).			
		Furnishing own material.		San Clemente Island stone.	
		Price.	Total.	Price.	Total.
1	Knapp & Gillen and Leathem & Smith, Racine, Wis			$1.07	$145,541.40
2	Hingston & Sylvester, Buffalo, N. Y	$0.70	$95,214.00	.65	88,413.00
3	Heidmaier & Neu, Chicago, Ill	.63	85,692.60	.54½	74,130.90
4	Smith H. Mallory, Chariton, Iowa	.79	107,455.80		
5	Rudolf Axman, San Pedro, Cal	.64	87,052.80		
6	California Construction Co., San Francisco, Cal.	.95	129,219.00	.87	118,337.40
7	The National Constructing Co., New York City	2.00	272,040.00	.97½	132,619.50
8	Griffiths & McDermott, Chicago, Ill	.82	111,536.40	.73	99,294.60
9	Grattan & Jennings, New York City	.92	125,138.40	.90	122,418.00
10	Hill, Abbot, O'Meara & Gamble, St. Louis, Mo	.87	118,337.40	.78	106,095.60
11	Jacob Friday & Sons, Pittsburg, Pa	1.19½	162,543.90	1.08½	147,581.70
12	Macdonald, Killebrew & Co., St. Louis, Mo	.89	121,057.80	.88 19/20	121,044.20
13	Warren, Malley & Day, San Francisco, Cal	.83	112,896.60		
14	W. L. Prather, jr., Oakland, Cal	.87 7/10	119,289.54	.77 7/10	105,687.54
15	Hale & Kern Construction Co., Portland, Oreg	.85	115,617.00	.80	108,816.00
16	William T. Gaynor, Fayetteville, N. Y	.85	115,617.00	.83	112,896.60
17	J. C. Bull, jr., Arcata, Cal			.99	134,659.80

* The remainder of the appropriation of $50,000 made by the river and harbor act of June 3, 1896, for deep-water harbor at Santa Monica Bay, or San Pedro Bay, California, was expended by the Board provided for by said act.

Abstract of bids for construction of breakwater at San Pedro, Cal., etc.—Continued.

	Name and address of bidder.	Substructure (1,933,603 tons).			
		Furnishing own material.		San Clemente Island stone.	
		Price.	Total.	Price.	Total.
1	Knapp & Gillen and Leathem & Smith, Racine, Wis			$1.07	$2,068,955.21
2	Hingston & Sylvester, Buffalo, N. Y.	$0.51	$986,137.53	.46	889,457.38
3	Heldmaier & Neu, Chicago, Ill	.63	1,218,169.89	.54½	1,053,813.64
4	Smith H. Mallory, Chariton, Iowa	.73	1,411,530.19		
5	Rudolf Axman, San Pedro, Cal	.70	1,353,522.10		
6	California Construction Co., San Francisco, Cal.	.95	1,836,922.85	.85	1,643,562.55
7	The National Constructing Co., New York City.	2.00	3,867,206.00	.97½	1,885,262.93
8	Griffiths & McDermott, Chicago, Ill	.78	1,508,210.34	.72	1,392,194.16
9	Grattan & Jennings, New York City	.92	1,778,914.76	.90	1,740,342.70
10	Hill, Abbot, O'Meara & Gamble, St. Louis, Mo	.87	1,682,234.61	.78	1,508,210.34
11	Jacob Friday & Sons, Pittsburg, Pa	1.19½	2,310,635.59	1.08½	2,097,959.26
12	Macdonald, Killebrew & Co., St. Louis, Mo	.89	1,720,906.67	.88 20/100	1,720,718.31
13	Warren, Malley & Day, San Francisco, Cal	.85	1,643,562.55		
14	W. L. Prather, jr., Oakland, Cal	.87 7/10	1,695,769.83	.77 7/10	1,502,409.53
15	Hale & Kern Construction Co., Portland, Oreg.	.85	1,643,562.55	.80	1,546,882.40
16	William T. Gaynor, Fayetteville, N. Y.	.85	1,643,562.55	.83	1,604,890.49
17	J. C. Bull, jr., Arcata, Cal			.99	1,914,268.97

	Name and address of bidder.	Superstructure (221,025 tons).			
		Furnishing own material.		San Clemente Island stone.	
		Price.	Total.	Price.	Total.
1	Knapp & Gillen and Leathem & Smith, Racine, Wis			$3.00	$663,075.00
2	Hingston & Sylvester, Buffalo, N. Y.	$1.90	$419,947.50	1.60	353,640.00
3	Heldmaier & Neu, Chicago, Ill.	1.66	366,901.50	.72	159,138.00
4	Smith H. Mallory, Chariton, Iowa	1.45	320,486.25		
5	Rudolf Axman, San Pedro, Cal	1.93	426,578.25		
6	California Construction Co., San Francisco, Cal.	2.95	652,023.75	2.90	640,972.50
7	The National Constructing Co., New York City.	2.00	442,050.00	.97½	215,499.38
8	Griffiths & McDermott, Chicago, Ill	1.75	386,793.75	1.70	375,742.50
9	Grattan & Jennings, New York City	2.00	442,050.00	1.75	386,793.75
10	Hill, Abbot, O'Meara & Gamble, St. Louis, Mo.	3.16	698,439.00	2.72	601,188.00
11	Jacob Friday & Sons, Pittsburg, Pa	1.19½	264,124.88	1.08½	239,812.13
12	Macdonald, Killebrew & Co., St. Louis, Mo	1.49	329,327.25	1.48 12/100	329,305.15
13	Warren, Malley & Day, San Francisco, Cal	3.00	663,075.00		
14	W. L. Prather, jr., Oakland, Cal.	2.79	616,659.75	2.59	572,454.75
15	Hale & Kern Construction Co., Portland, Oreg.	2.25	497,306.25	1.75	386,793.75
16	William T. Gaynor, Fayetteville, N. Y.	1.49	329,327.25	1.47	324,906.75
17	J. C. Bull, jr., Arcata, Cal			.99	218,814.75

	Name and address of bidder.	Concrete (2,370 cubic yards).		Total.	
		Price.	Total.	Furnishing own material.	San Clemente Island stone.
1	Knapp & Gillen and Leathem & Smith, Racine, Wis	$6.00	$14,220.00		$2,891,791.61
2	Hingston & Sylvester, Buffalo, N. Y	7.50	17,775.00	$1,519,074.03	1,349,385.38
3	Heldmaier & Neu, Chicago, Ill	6.80	16,116.00	1,686,879.99	1,303,198.54
4	Smith H. Mallory, Chariton, Iowa	4.00	9,480.00	1,848,952.24	
5	Rudolf Axman, San Pedro, Cal	8.00	18,960.00	1,886,113.15	
6	California Construction Co., San Francisco, Cal.	5.65	13,390.50	2,631,556.10	2,416,262.85
7	The National Constructing Co., New York City.	6.00	14,220.00	4,595,516.00	2,247,601.81
8	Griffiths & McDermott, Chicago, Ill	6.50	15,405.00	2,021,945.49	1,882,636.25
9	Grattan & Jennings, New York City	5.00	11,850.00	2,357,953.16	2,261,314.45
10	Hill, Abbot, O'Meara & Gamble, St. Louis, Mo.	6.00	14,220.00	2,513,281.01	2,223,712.94
11	Jacob Friday & Sons, Pittsburg, Pa	5.00	11,850.00	2,749,174.37	2,497,293.00
12	Macdonald, Killebrew & Co., St. Louis, Mo	6.00	14,220.00	2,185,511.72	2,185,282.68
13	Warren, Malley & Day, San Francisco, Cal	6.50	15,405.00	2,434,939.15	
14	W. L. Prather, jr., Oakland, Cal.	5.00	11,850.00	2,443,569.12	2,192,461.53
15	Hale & Kern Construction Co., Portland, Oreg.	6.00	14,220.00	2,270,705.80	2,056,712.15
16	William T. Gaynor, Fayetteville, N. Y.	9.00	21,330.00	2,109,836.80	2,064,623.94
17	J. C. Bull, jr., Arcata, Cal	9.63	22,823.10		2,290,584.63

COMMERCIAL STATISTICS FOR THE YEAR ENDING DECEMBER 31, 1897.

For the commercial statistics, see report of Wilmington Harbor, Cal.

R R 3.

IMPROVEMENT OF WILMINGTON HARBOR, CALIFORNIA.

No appropriation had been made for this harbor since 1892 until the river and harbor act of June 3, 1896, which appropriated $50,000 for improving the harbor in accordance with the project submitted February 7, 1895, and authorized the Secretary of War to enter into contracts for such materials and work as might be necessary to complete the project, not to exceed in the aggregate $342,000, exclusive of the $50,000 appropriated, but no such contracts were to be entered into until the Board provided for in the same act to determine the location of a deep-water harbor for commerce and of refuge as between Port Los Angeles, in Santa Monica Bay, and San Pedro had made its report to the Secretary of War, and not at all if such report should be in favor of San Pedro as the location of the harbor.

Owing to the proviso mentioned, no work has been done during the fiscal year ending June 30, 1898.

The total amount expended to June 30, 1898, including outstanding liabilities, is $953,539.

Money statement.

July 1, 1897, balance unexpended	$52,146.57
June 30, 1898, amount expended during fiscal year	685.57
July 1, 1898, balance unexpended	51,461.00
July 1, 1898, outstanding liabilities	40.00
July 1, 1898, balance available	51,421.00

Amount and date of all appropriations for the work.

March 3, 1871	$200,000	July 5, 1884	$50,000
June 10, 1872	75,000	August 5, 1886	75,000
March 3, 1873	150,000	August 11, 1888	90,000
March 3, 1875	30,000	September 19, 1890	34,000
June 18, 1878	20,000	July 13, 1892	51,000
March 3, 1879	12,000	June 3, 1896	50,000
June 14, 1880	35,000		
March 3, 1881	33,000	Total	1,005,000
August 2, 1882	100,000		

Commercial statistics for the year the improvement began (1871).

	Incoming.	Outgoing.
Vessels:		
Steam	160	160
Sailing	65	65
Total	225	225
Freight, tons	25,313	9,575
Lumber, feet	10,938,336	.....

Statistics of commerce for the year ending December 31, 1897.

[Furnished by the collector of customs at Los Angeles, Cal.]

	Incoming.	Outgoing.
Vessels:		
Steam	240	242
Sailing	172	173
Total	412	415
Tonnage	138,070	138,235
Draft, greatest.....feet..	18.6	18.6
Merchandise, general.....tons..	5,970	2,605
Lumber.....feet..	108,550,000	.....

	Tons.
Total amount of freight entered and cleared in 1871	50,059
Total amount of freight entered and cleared in 1897	225,675
Increase	175,616

No new lines of transportation were established during the year.

R R 4.

IMPROVEMENT OF SAN LUIS OBISPO HARBOR, CALIFORNIA.

On July 1, 1897, a contract for continuing the construction of the breakwater was entered into with the City Street Improvement Company, of San Francisco, Cal., at $1.99 per ton of 2,240 pounds. This was approved by the Chief of Engineers July 16, 1897. Time of commencement, July 13, 1897; time of completion, January 1, 1899.

Previous to this contract the stone for the breakwater had been obtained from the quarries at Morro, about 20 miles to the northward of Port Harford, and had to be towed in barges by sea. Under this contract the stone was obtained from a quarry near San Luis Obispo, being brought by rail via Pacific Coast Railway, an incline 2,500 feet long, with a 16 per cent grade and 3-foot gauge, being built, connecting the quarry with the railway. The stone was landed in cars on the wharf at Port Harford, and thence loaded on barges and towed to the site of the work. The inclined track was completed, the quarry opened, and the water plant in working order, so that actual delivery of stone was commenced in October, 1897. The delivery of stone was carried on continuously until June 8, 1898, when the contract was completed, 22,595.73 tons of stone being placed in the work, of which amount 2,230.57 tons were used in repairing the inner breakwater and raising the crest to about 10½ feet above low tide; the remainder of the stone was used in repairs and in extending the outer breakwater.

The stone was not as good in quality as that obtained from the Morro quarries, being more friable and having many fine veins of calcite running through it which effervesced with acid. Specimens of the rock were sent to the department of geology and mineralogy of the University of California, and the following professional opinion obtained:

Such a rock can not be considered as desirable as a good granite, but it is safe to say that if the rock is satisfactory when first put in (i. e., if it will withstand the mechanical attack of the waves) it will not be materially affected by the salt water, and will have a reasonably long existence.

Experience in handling the rock showed that it was apt to break up, and consequently considerable stone was rejected.

Experience having shown that the portion of the breakwater beyond Whaler Island was subjected to a very heavy sea, knocking over some of the heaviest stone and sluing the end of the breakwater around toward the harbor side, the rocky bottom affording rather poor holding ground for the stone, a deflection of about 11 degrees was made in the line of direction, to see if this would not remedy matters. It has apparently somewhat improved conditions, the waves breaking on the crest of the reef before reaching the breakwater; but only a survey after a season's storms will definitely determine this matter. The original direction was probably taken along the line of shoalest water to save material. The deflected line will be in deeper water, but a shorter length will protect an equal area of the harbor.

The present status of the work is as follows: Total length of breakwater when completed will be 1,981 feet. Of this 1,091 feet, including Whaler Island, has been completed up to grade, 6 feet above high water; 280 feet up to and above high water, and 40 feet up to mean low water.

The total amount expended to June 30, 1898, is $171,465.13.

Money statement.

July 1, 1897, balance unexpended	$52,380.15
June 30, 1898, amount expended during fiscal year	48,845.28
July 1, 1898, balance unexpended	3,534.87
Amount (estimated) required for completion of existing project	393,660.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	150,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for the work.

August 11, 1888	$25,000
September 19, 1890	40,000
July 13, 1892	30,000
August 18, 1894	40,000
June 3, 1896	40,000
Total	175,000

Commercial statistics.

[Statistics furnished by the Pacific Coast Railway Company.]

	Year the improvement began (1888).		Year ending December 31, 1897.	
	Incoming.	Outgoing.	Incoming.	Outgoing.
Vessels:				
Steam	603	603	453	453
Sailing	34	34	2	2
Total	637	637	455	455
Tonnage	452,149.34	452,149.34	12,407	40,456
Draft, greatest, feet	18	.....	18½	18½
Merchandise, general, tons	8,802	5,669	5,343	.....
Coal, do	2,985	.....	.....	.....
Lumber, feet	8,884,400	.....	2,256,000	.....
Grain, tons	.....	23,305	2	22,442
Bituminous rock, do	.....	15,342	.....	703
Dairy produce, do	.....	.....	.....	1,210
Live stock, do	.....	.....	14	1,145
Asphaltum, do	.....	.....	81	697
Stone, do	.....	.....	127	5,973
Miscellaneous, do	.....	.....	2,328	1,288

	Tons.
Total amount of freight entered and cleared in 1888	68,425
Total amount of freight entered and cleared in 1897	52,863
Decrease	15,562

No new lines of transportation have been established during the year.

APPENDIX S S.

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA, SAN JOAQUIN AND SACRAMENTO RIVERS AND TRIBUTARIES, AND OF RIVERS AND HARBORS IN CALIFORNIA NORTH OF SAN FRANCISCO.

REPORT OF MAJ. W. H. HEUER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Oakland Harbor, California.
2. San Joaquin River, California.
3. Mokelumne River, California.
4. Sacramento and Feather rivers, California.
5. Napa River, California.
6. Petaluma Creek, California.
7. Humboldt Harbor and Bay, California.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 14, 1898.

GENERAL: I have the honor to transmit herewith my annual reports for the fiscal year ending June 30, 1898. These works were in charge of Capt. Cassius E. Gillette, Corps of Engineers, to July 7, 1897, and from that date to October 18, 1897, in charge of Maj. Chas. E. L. B. Davis, Corps of Engineers.

Very respectfully, your obedient servant,

W. H. HEUER,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

S S 1.

IMPROVEMENT OF OAKLAND HARBOR, CALIFORNIA.

[This work was in the charge of Col. Chas. R. Suter, Corps of Engineers, to November 16, 1897.]

Full details of the original depth, width of channel, and commercial availability, together with the original project of 1874 and all important alterations and additions up to date, can be found in the Annual Report of the Chief of Engineers for 1897, page 3327.

The present condition of the improvement for navigable purposes is practically the same as then reported, with the exception of the 200-foot channel in the tidal basin, which has shoaled 6 inches during the year and now furnishes 6 feet at low water, the banks sloughing in so as to reduce the width somewhat.

The least depth of water encountered by merchant vessels entering this harbor is at the bar near the mouth of the jetties, namely, 13 feet at low water or 19 feet at high water spring, the same as reported for years past.

In compliance with the orders of the Secretary of War, May 20, 1896, the Southern Pacific Company began the construction of a new railroad bridge at Harrison street on March 15, 1898. The Alameda County authorities have taken all the preliminary steps toward reconstructing the Webster street bridge, but progress has been delayed by a recent protest, which calls for a public hearing early in the coming fiscal year.

During the fiscal year the sum of $4,821.60 was expended on this work, making the total amount expended to June 30, 1898, $1,781,270.82.

No operations other than sundry surveys and ordinary repair work have been going on during the fiscal year.

No old contracts were in force at the beginning of the year.

A new dredging contract was entered into with the San Francisco Bridge Company on April 5, 1898, for continuing the 20-foot channel westerly to San Francisco Bay, and operations are required to begin on or before June 30, 1898. This contract involves the removal of 650,000 cubic yards, more or less. Bids were called for January 22 and opened March 10, 1898.

Money statement.

July 1, 1897, balance unexpended	$228,150.78
Amount appropriated by sundry civil act approved July 1, 1898	133,000.00
	361,150.78
June 30, 1898, amount expended during fiscal year	4,821.60
July 1, 1898, balance unexpended	356,329.18
July 1, 1898, amount covered by uncompleted contracts	101,500.00
July 1, 1898, balance available	254,829.18
Amount (estimated) required for completion of existing project	388,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	130,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

List of appropriations for improving harbor at Oakland, Cal.

June 23, 1874	$100,000	August 11, 1888	$350,000
March 3, 1875	100,000	September 19, 1890	250,000
August 4, 1876	75,000	July 13, 1892	150,000
June 18, 1878	80,000	August 18, 1894	100,000
March 3, 1879	60,000	June 3, 1896	20,000
June 14, 1880	60,000	June 4, 1897	200,000
March 3, 1881	60,000	July 1, 1898	133,000
August 2, 1882	200,000		
July 5, 1884	139,600	Total	2,137,600
August 5, 1885	60,000		

Abstract of bids for dredging in Oakland Harbor, California, received and opened by Maj. W. H. Heuer, Corps of Engineers, on March 10, 1898, in answer to advertisements dated January 22, 1898.

	Name and address of bidder.	Jetty channel (600,000 cubic yards).		City front channel (50,000 cubic yards).		Total.
		Per cubic yard.	Total.	Per cubic yard.	Total.	
1	Pacific Coast Dredging and Reclamation Company, San Francisco, Cal	$0.18	$108,000	$0.41	$20,500	$128,500
2	San Francisco Bridge Company, San Francisco, Cal	.13	78,000	.47	23,500	101,500
3	W. L. Prather, jr., Oakland, Cal	.2474	148,440	.2474	12,370	160,810
4	Bowers California Dredging Company, San Francisco, Cal	.223	132,400	.3857	19,285	151,685
5	A. C. Hamilton, San Francisco, Cal	.1845	110,700	.13	6,000	116,700

LIST OF ALL CONTRACTS IN FORCE ON ACCOUNT OF IMPROVING HARBOR AT OAKLAND, CAL.

Contract dated April 5, 1898, for dredging in Oakland Harbor, California.

Name of contractor.	Date of approval.	Work commenced.
San Francisco Bridge Company	April 5, 1898	June 28, 1898

The expiration of this contract is indefinite. The contractor must earn $12,000 per month until the areas specified in the contract for dredging are completed.

COMMERCIAL STATISTICS.

The following is a tabulated statement showing the increase in traffic by vessels and steamers passing through the jetty channel during the past calendar years:

The classified freight, embracing staple articles, carried by merchant vessels entering this port during the past year, comprises 400,660 tons, composed as follows:

	Tons.
Wood, coal, and coke	189,460
Hay, grain, and flour	8,700
Lumber	107,850
Building materials	53,390
Sundries	41,260
Total	400,660

Or 34,000 tons more than last year.

It is impracticable to classify the freight transported by steam ferries, which last year amounted to 2,283,171 tons of miscellaneous merchandise, showing an annual increase of 151,680 tons as compared with the previous year's report.

Year.	Number.	Traffic by ferries.			Traffic by vessels.		
		Trips.	Passengers.	Freight.	Number.	Register.	Freight.
				Tons.		*Tons.*	*Tons.*
1874	1	600	.....	60,000	1,415	70,750	94,800
1878	3	5,400	216,240	129,000	1,085	109,125	211,627
1881	3	8,800	858,352	1,051,788	1,129	129,714	173,448
1882	3	9,400	892,210	1,150,379	1,004	144,004	257,614
1883	3	8,000	974,901	1,142,918	1,031	143,886	215,829
1884	3	8,000	1,553,769	1,202,230	1,156	163,553	255,738
1885	3	6,000	444,142	1,489,134	1,326	200,223	305,437
1886	3	6,000	318,402	1,457,924	1,673	188,974	264,050
1887	3	8,520	210,423	1,654,451	1,224	130,913	231,660
1888	3	8,520	200,000	1,876,635	1,384	162,957	295,932
1889	3	8,600	100,000	1,755,247	1,745	185,358	338,123
1890	3	8,600	100,000	1,925,957	2,153	213,971	393,478
1891	3	8,600	100,000	2,259,086	2,310	232,706	437,923
1892	3	8,600	96,000	2,202,170	2,277	223,148	443,011
1893	5	10,521	506,125	2,142,460	1,688	195,000	306,885
1894	4	9,561	554,932	2,119,267	1,741	175,750	309,350
1895	4	9,600	335,868	2,188,908	1,966	200,070	349,788
1896	5	10,500	249,843	2,131,491	1,946	208,155	366,098
1897	5	10,500	248,160	2,283,171	1,382	256,325	340,660

The following comparative grand totals of general traffic through the jetty channel shows important growth in water transportation in the past twenty-three years:

General traffic.	1874, before improvement.		1897, after improvement.	
	Passengers.	Freight.	Passengers.	Freight.
		Tons.		*Tons.*
By ferries	None	60,000	248,160	2,283,171
By vessels	None	94,800	.....	340,660
Grand total	.....	154,800	248,160	2,623,831

S S 2.

IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

A description of this stream, its original condition, and the plan for its improvement are given in the Annual Report of the Chief of Engineers for 1896, page 3189.

Report of operations for the fiscal year ending June 30, 1898.—During this year there has been expended on the improvement of this river $21,668.66, the work done being dredging to maintain the required depth to Stockton, removing obstructions in the upper river, and enlarging the cuts at Head Reach and Twenty-one Mile Slough.

In July, 1897, the river fell so as to cause a shoaling in Stockton Slough, which seriously interfered with navigation. The United States dredge was immediately put in commission, and work was commenced on July 22, just below the junction of Stockton and Mormon sloughs. The shoal, which extended for about 3,000 feet down the river from that point, was removed by October 19, when, there being no further obstruction to navigation, the dredge was laid up in Mormon Slough. The work necessitated the removal of 91,988 cubic yards of material, which was pumped on shore on the south side of the slough. The cost was $4,567.62, or 5.3 cents per cubic yard. At the beginning of July, 1897, a sand bar formed at Grayson, in the upper river, which impeded navigation to a considerable extent. A temporary wing dam was built out from the west bank of the river, which removed the bar and enabled boats to pass without interruption. The cost of this work was $191.75.

In December, 1897, a small party was sent to Bell's Landing, in the upper river, where some obstructions had formed in a natural cut-off used for navigation. These were removed by blasting and the channel cleared. The party then went to Morrison Bend, where the river had made a channel through an old dredger cut made in building a levee. Several hard-pan shoals were blasted out of this cut, leaving it free for navigation. The cost of this work was $98.50.

At the end of the month of January, 1898, a shoal formed in the channel at the junction of the double cut-off at the narrows with the main river, and increased so rapidly that it threatened to stop navigation between Stockton and San Francisco. As the United States dredge was laid up and in need of repairs, a dredge which was in the neighborhood was hired and the shoal removed, leaving navigation free and open. In doing this work, which cost $270, about 3,000 cubic yards of sand was dredged and placed on shore.

On October 6, 1897, bids were opened for dredging to increase the size of the cut offs at Head Reach and Twenty-one Mile Slough. Both contracts were awarded to Mr. James C. Smith, of Stockton, Cal., for 5½ cents per cubic yard.

Work was commenced at Head Reach on November 19, 1897, and completed on January 4, 1898, the cut when completed being 200 feet wide on the bottom and 230 feet wide on the top, with a least depth of 10 feet at low water. To do this work 104,146 cubic yards of material were excavated and placed on shore, far enough back from the edge of the banks to prevent caving. The total cost of the work was $5,997.04.

The contractor commenced work at Twenty-one Mile Slough on January 16, 1898, and completed it on March 21, 1898. This cut when completed was also 200 feet wide on the bottom and 230 feet wide on the top, with a least depth of 10 feet at low water. In this work 186,344 cubic yards of material were excavated and placed securely on shore, the total cost being $10,543.75.

The width and depth of these two cuts now afford free and ample accommodation for all boats using the river.

Future operations.—Extensive annual dredging will be required in Stockton Channel to maintain the requisite depth for the important commerce between Stockton and San Francisco, and some work of small extent will be required in the upper river. To maintain the widths and depths required by the approved project, it is estimated that $20,000 will be required during the fiscal year ending June 30, 1900.

Money statement.

July 1, 1897, balance unexpended	$68,746.13
June 30, 1898, amount expended during fiscal year	21,670.71
July 1, 1898, balance unexpended	47,075.42
Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	20,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving San Joaquin River, California.

August 14, 1876	$20,000	September 19, 1890	$75,000
June 14, 1880	20,000	July 13, 1892	65,000
March 3, 1881	40,000	August 18, 1894	50,000
August 2, 1882	40,000	June 3, 1896	57,750
July 5, 1884	20,000		
August 5, 1886	18,750	Total	431,500
August 11, 1888	25,000		

Abstract of bids for dredging at Head Reach and Twenty-one Mile Slough, in the San Joaquin River, California, received and opened by Maj. Chas. E. L. B. Davis, Corps of Engineers, this 6th day of October, 1897, in answer to advertisement dated September 1, 1897.

HEAD REACH.

No.	Name and address of bidder.	Price per cubic yard.	Total for 98,200 cubic yards.
		Cents.	
1	James C. Smith, Stockton, Cal	5.50	$5,126.00
2	Pacific Coast Dredging and Reclamation Co., San Francisco, Cal	9.90	9,226.00
3	W. C. White, Stockton, Cal	7	6,524.00
4	T. H. Sellers, San Francisco, Cal	6.70	6,244.00
5	John W. Ferris, San Francisco, Cal	6	5,592.00
6	J. M. Taylor, San Francisco, Cal	10.74	10,000.68
7	Willis G. Witter, San Francisco, Cal	6	5,592.00

TWENTY-ONE MILE SLOUGH.

No.	Name and address of bidder.	Price per cubic yard.	Total for 175,864 cubic yards.
		Cents.	
1	James C. Smith, Stockton, Cal	5.50	$9,672.52
2	Pacific Coast Dredging and Reclamation Co., San Francisco, Cal	9.90	17,410.54
3	W. C. White, Stockton, Cal	No bid.	
4	T. H. Sellers, San Francisco, Cal	6.70	11,782.89
5	John W. Ferris, San Francisco, Cal	6	10,551.84
6	J. M. Taylor, San Francisco, Cal	10.74	18,887.78
7	Willis G. Witter, San Francisco, Cal	6	10,551.84

* Indeterminate.

LIST OF ALL CONTRACTS IN FORCE DURING THE FISCAL YEAR 1898 ON ACCOUNT OF IMPROVING SAN JOAQUIN RIVER, CALIFORNIA.

Contract dated November 8, 1897, for dredging in San Joaquin River, near Head Reach, California.

Name of contractor.	Date of approval.	Work commenced.	Work completed.
James C. Smith	Nov. 22, 1897	Nov. 19, 1897	Jan. 4, 1898

Contract dated November 18, 1897, for dredging at Twenty-one Mile Slough, San Joaquin River, California.

Name of contractor.	Date of approval.	Work commenced.	Work completed.
James C. Smith	Nov. 29, 1897	Jan. 14, 1898	Mar. 22, 1898

Statistics of commerce on the San Joaquin River, California.

The following is a statement of the business done by the California Navigation and Improvement Company on the San Joaquin River, California, during the calendar year 1897, which was furnished by Capt. H. J. Corcoran, manager of the company.

	Tons.	Tons.
Lower San Joaquin River:		
Grain	90,198	
Mill stuffs	62,697	
Coal	15,662	
Lumber	66,678	
Produce	57,000	
Wool	1,200	
Merchandise	73,525	
Live stock	14,181	
		381,141
Upper San Joaquin River:		
Lumber	1,600	
Wheat	9,149	
Merchandise	1,842	
Miscellaneous	1,500	
		14,091
Total		395,232
Passengers		112,039

The following is a statement of the freight carried by the Union Transportation Company during the calendar year 1897:

	Tons.
General freight	59,723

Small scow schooners also carry a large amount of freight on this river, but it is impossible to obtain a statement of the amount.

Comparative yearly statement of freight transported on the San Joaquin River, California.

Year.	Passengers.	Freight.	Year.	Passengers.	Freight.
		Tons.			Tons.
1881	.....	230,324	1894	154,509	346,694
1882	.....	152,250	1895	100,178	295,651
1891	57,840	527,684	1896	61,531	461,694
1892	56,000	370,000	1897	97,889	431,736
1893	90,000	395,000	1898	112,039	454,655

S S 3.

IMPROVEMENT OF MOKELUMNE RIVER, CALIFORNIA.

A description of this river, its original condition, the plan for its improvement, and the results obtained are given in the Annual Report of the Chief of Engineers for 1896, page 3193.

Report of operations for the fiscal year ending June 30, 1898: No work has been done on this river during the past fiscal year and no funds expended.

Remarks.—During the year one steamer, the *Constance* (385 tons), has run regularly to New Hope Landing, about 11 miles above mouth of river, making three round trips per week. No other steamer has run on the river, although a few scow schooners make irregular trips there. There has been little or no navigation above New Hope Landing.

Future operations.—There is no impediment to navigation between the mouth of Mokelumne River and New Hope Landing. Above that point there is about 3 miles of river from the banks of which the trees might be cut with advantage to navigation, but as there is little, if any, navigation there, no necessity for this exists at present. Should the necessity for this arise, the funds on hand are sufficient for the purpose.

Money statement.

July 1, 1897, balance unexpended	$888.34
July 1, 1898, balance unexpended	888.34

Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	(†)
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of appropriations for improving Mokelumne River, California.

July 5, 1884	$8,500
August 5, 1886	2,500
August 11, 1888	2,000
July 13, 1892	2,500
August 18, 1894	2,500
Total	18,000

COMMERCIAL STATISTICS.

The following is the business done on the Mokelumne River, by the steamer of the California Transportation Company, the *Constance*, which runs between San Francisco and New Hope Landing, during the year 1897:

Freight	tons	52,771
Passengers	number	6,081

A large amount of freight is also carried on the various scow schooners which run on the river, but it is impossible to obtain any statement of their business.

* Indeterminate. † Sufficient on hand.

S S 4.

IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS, CALIFORNIA.

A description of this stream, its original condition, and the plan for its improvement, are given in the Annual Report of the Chief of Engineers for 1896, page 3195.

Report of operations for the fiscal year ending June 30, 1898.—During the year $30,292.98 has been expended on snagging, building wing dams, repairing the dam at Parrott Bend, and completing the survey of the river.

The snag boat *Seizer* commenced work on July 1, 1897, in the upper river, removing snags and building wing dams to wash out shoals at such places as offered obstructions to navigation. This work was continued until early in September, when a serious sand bar formed just below the city of Sacramento, which necessitated the bringing of the boat to that point. Two wing dams were built there, which removed the shoal and relieved the obstruction to navigation. As soon as this was done the boat went down the stream to the lower river, removing all snags there which obstructed navigation, and also did some work in Georgiana Slough. The upper river was then again cleared of a few small obstructions which remained, and on December 8, 1897, the river being in good condition to the head of navigation, the snag boat was laid up for the season.

In July wing dams were built by the snag boat at Jenning's bar, aggregating 250 feet in length, and at Dover Chute, aggregating 280 feet in length; in August, at Call's bend, aggregating 325 feet in length, and Monroeville, aggregating 200 feet in length; in September, at Sacramento, aggregating 334 feet in length, and in October another wing dam was built at Dover Chute 80 feet in length.

During the season 1,159 snags were removed from the river and 213 overhanging trees cut from its banks; 1,094 blasts were fired, using 4,281 pounds of No. 1 dynamite. The boat ran 2,004 miles. The cost of the season's snagging was $16,743.43.

On January 5, 1898, a small force, consisting of 12 men and 8 pairs of horses, was put to work to repair the dam at Parrott Bend. All the low places where the dam had settled were raised to full height and the dam put in condition to stand ordinary high water. The work was completed in 9 days and cost $488.16.

During the low water of 1897 the field work of the survey of the Sacramento River, which had been carried as far downstream as Princeton in 1896, was completed, The work was plotted during the winter and is now finished. This survey was made for the Board of Engineers appointed under the act of Congress of June 3, 1896.

Future operations.—In order to keep the river in proper navigable condition, it will be necessary that the snags which are formed by each winter's floods should be removed. To carry this work on to the end of the fiscal year ending June 30, 1900, will, it is estimated, cost $25,000, in addition to the funds already on hand.

Remarks.—The act of Congress passed June 3, 1896, provided for the construction, by the California Débris Commission, of restraining barriers for the protection of the Sacramento River, and also provides for placing the improvement of these rivers under a board of three engineer officers. For these reasons no estimate of funds to carry on the present project, beyond snagging, is presented.

Money statement.

July 1, 1897, balance unexpended	$80,774.29
June 30, 1898, amount expended during fiscal year	30,292.98
July 1, 1898, balance unexpended	50,481.31
Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	25,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Amount and date of all appropriations for improving Sacramento and Feather rivers, California.

March 3, 1875	$15,000	August 11, 1888	$20,000
June 18, 1878	15,000	September 19, 1890	30,000
March 3, 1879	20,000	July 13, 1892	150,000
June 14, 1880	45,000	August 18, 1894	115,000
March 3, 1881	60,000		
August 2, 1882	250,000	Total	760,000
July 5, 1884	40,000		

Statistics of commerce of the Sacramento and Feather rivers, California, for the calendar year 1897.

The following freight was carried by the boats of the California Transportation Company between San Francisco and Clarksburg, a distance of 110 miles:

Produce and coal	tons	75,293
Lumber	do	10,320
Total		85,613
Passengers	number	10,860

The following is a statement of the freight carried by the boats of the Southern Pacific Company between San Francisco and Sacramento, including all way freight:

	Tons.
Total freight north and south	130,313

The following is a statement of the freight carried by the Sacramento Transportation Company, the only company running boats on the Sacramento River above the city of Sacramento:

	Tons.	Tons.
From San Francisco to Sacramento:		
Lumber	16,000	
Merchandise	13,356	
Coal	13,420	
From Sacramento to San Francisco:		
Brick	27 500	
Merchandise	2,000	
Miscellaneous	1,100	
Total freight between San Francisco and Sacramento		73,376
River above Sacramento:		
Down-river freight—		
Wheat and barley	70,853	
Wood	8,000	
Broom corn	250	
Indian corn	1,240	
Potatoes	2,400	
Hogs and cattle	230	
Hay	2,500	
Miscellaneous	800	

* Indeterminate.

River above Sacramento—Continued.	Tons.	Tons.
Up-river freight—		
Merchandise to points below Red Bluff	8,000	
Merchandise to Red Bluff	8,100	
Up-river points to San Francisco—Merchandise	2,650	
Up-river points to Sacramento—Merchandise	350	
Total freight of upper river		105,373
Total freight carried		178,749

The commerce of the Sacramento River is carried on 8 steamers, 16 grain barges, and 7 brick barges belonging to the Sacramento Transportation Company; 5 steamers and 7 barges belonging to the California Transportation Company, and 2 steamers belonging to the Southern Pacific Company. The steamers vary in size from 183 to 619 tons, and the barges from 118 to 800 tons. The larger of the steamers only go a short distance up the river, the commerce of the upper river being carried on barges towed by light-draft steamers.

On the Feather River a small steamer, 247 tons gross tonnage, belonging to the Southern Pacific Company, makes one round trip each week with a barge, and takes all the freight that offers. The following is a statement of the freight carried during the calendar year 1897:

	Tons.
Freight north and south	4,313

This includes all way freight.

Comparative yearly statement of freight transported on the Sacramento River, California.

Year.	Passengers.	Freight.	Year.	Passengers.	Freight.
		Tons.			*Tons.*
1878		167,000	1893	14,102	466,343
1879		200,925	1894	13,000	358,014
1880		201,000	1895		413,647
1881		279,659	1896	12,108	363,658
1890		249,105	1897	11,608	422,111
1891	15,650	353,056	1898	10,860	394,675
1892	14,455	579,574			

PRELIMINARY REPORT OF THE BOARD OF ENGINEERS ON IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS.

[Printed in House Doc. No. 186, Fifty-fifth Congress, second session.]

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., December 14, 1897.

GENERAL: The Board of Engineers constituted by Special Orders, No. 18, Headquarters Corps of Engineers, July 27, 1896, by virtue of the river and harbor act of June 3, 1896, of which the following is an extract—

Improving Sacramento and Feather rivers and their tributaries, California: The Secretary of War is hereby authorized and directed to appoint a board, consisting of three engineers of the United States Army, for the purpose of making surveys and examinations of said rivers and submit the most feasible plan for the improvement of said rivers and the maintenance of navigation thereon, and to have charge of the work by them recommended as appropriations are made therefor; said board may, under the direction of said Secretary of War, expend any balance now remaining to the credit of said rivers in the improvement of the same, after deducting the expense of said surveys and examinations—

has the honor to submit the following preliminary report with reference to the improvement of the Sacramento River below Sacramento:

This report is based on surveys completed in 1895, which extend from Sacramento to the mouth of the river. In the Annual Report of the

Chief of Engineers for 1891 will be found the reports of two Boards of Engineers on the improvement of the Sacramento River. Each considered that a least depth of 7 feet in the river at low-water stage was sufficient for the commerce carried on the river, with which opinion this Board agrees. The places where 7 feet, or less, depth of water occurs are known as Iron House Shoals, foot of Ida Island, head of Ida Island, near Clarksburg, vicinity of Heacock Shoals, and opposite to and just below the city of Sacramento. The Board, after careful consideration, believes that depths of 7 to 8 feet at low-water stages of the river can be obtained by contraction works at these separate localities, where the river is in all cases abnormally wide; these works to be of the nature of pile and brush work consisting of two parallel rows of piles extending from the bank out into the stream as far as may be required, packing in between these piles with brush held in position by rock placed on top, also by brush aprons placed above, below, and at the outer end of each of these wing dams, supplemented by dredging, if this should be required. The aggregate length of wing dams believed to be necessary is about 18,650 linear feet, estimated, with the bank protection, to cost $14 per linear foot, or $261,000. The dredging, if required, is estimated to cost $18,750, making, in round numbers, a total of $280,000.

The survey of that portion of the Sacramento River above the city of Sacramento is not yet platted, and a project and estimate for that portion of the river can not, therefore, as yet be submitted.

Respectfully submitted.

CHAS. R. SUTER,
Colonel, Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.
CHAS. E. L. B. DAVIS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF THE BOARD OF ENGINEERS ON IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS.

UNITED STATES ENGINEER OFFICE,
San Francisco, Cal., July 14, 1898.

GENERAL: The Board of Engineers constituted by Special Orders No. 18, Headquarters Corps of Engineers, U. S. A., July 27, 1896, and by virtue of the river and harbor act of June 3, 1896, of which the following is an extract—

Improving Sacramento and Feather rivers and their tributaries, California: The Secretary of War is hereby authorized and directed to appoint a board, consisting of three engineers of the United States Army, for the purpose of making surveys and examinations of said rivers and submit the most feasible plan for improvement of said rivers and the maintenance of navigation thereon, and to have charge of the work by them recommended as appropriations are made therefor; said board may, under the direction of said Secretary of War, expend any balance now remaining to the credit of said rivers in the improvement of the same, after deducting the expense of said surveys and examinations—

have the honor to submit its annual report on improving Sacramento and Feather rivers and their tributaries.

Under the direction of the Board, the surveys of the Sacramento and Feather rivers have been completed. The tracings and profiles of the rivers are yet, however, in an incomplete condition, owing to the fact that the draftsmen and engineers engaged on this work had to be taken away from it in consequence of the outbreak of the present war, and were placed on the more important and urgent work of national defense.

In the past year the Board has had six meetings to consider matters submitted by the commissioner of public works of the State of California for river improvement, and it also submitted a preliminary report and estimate, under date of December 14, 1897, for the improvement of that portion of the Sacramento River included between its mouth and the city of Sacramento. The general plan was to contract the width of the river, in places where it was abnormally wide and where shoals existed, by means of wing dams supplemented by dredging, if necessary, at an estimated cost of $280,000.

During the past year there has been no serious interruption to navigation on account of shoal water. The past winter has been remarkable for the exceptionally small amount of rainfall in the valley, which may cause an unusually low stage of water in the river during the coming summer and autumn.

Work has been continued during the fiscal year just closed by removing snags and building temporary wing dams, in accordance with the existing project.

The unexpended balances remaining from former appropriations, amounting to $50,481.31, together with the $280,000 estimated for by the Board, but not yet appropriated, it is believed will be sufficient to maintain fairly good navigation up to June 30, 1900.

Respectfully submitted.

CHAS. R. SUTER,
Colonel, Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.
CHAS. E. L. B. DAVIS,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

S S 5.

IMPROVEMENT OF NAPA RIVER, CALIFORNIA.

A description of this river, its original condition, the plan for its improvement, and the results obtained, are given in the Annual Report of the Chief of Engineers for 1896, page 3177.

Report of operations for the fiscal year ending June 30, 1898.—No work has been done on this river during the fiscal year, and no funds have been expended.

Remarks.—Permanent improvement of this stream is impracticable, as a channel dredged one year is liable to be obliterated by the detritus brought down by the floods of the succeeding winter. It has therefore been considered that, to keep the river in good navigable condition, dredging should be continued from year to year; and as the ordinary tides rise 5, and the spring tides 7 feet, a comparatively small amount of work is necessary to keep navigation in good condition for the class of boats that ply on the river.

Future operations.—As there is $4,162.70 available for work on this river, it is intended to dredge such bars as have formed and obstruct navigation; but as the winter floods will again fill the river, the improvement will be only temporary. It it estimated that $5,000 can be profitably expended on this river during the fiscal year ending June 30, 1900.

Money statement.

July 1, 1897, balance unexpended	$4,162.70
July 1, 1898, balance unexpended	4,162.70
Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	(†)
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for improving Napa River, California.

August 11, 1888	$7,500
September 19, 1890	10,000
August 18, 1894	4,000
June 3, 1896	4,000
Total	25,000

Commercial statistics.

Articles.		1884.	1897.
Merchandise, general, received and shipped	tons	22,800	17,250
Coal received	do	5,000	14,750
Hay shipped	do	2,000	2,100
Grain received and shipped	do	3,000	6,550
Wine received and shipped	do	7,500	4,900
Lumber received	do	18,333	12,500
Miscellaneous freight received and shipped	do	5,936	2,850
Total	do	64,569	60,900
Steamers		2	2
Tonnage		176	527
Trips by steamer		.....	Daily.

No new lines of transportation were established during the year.

S S 6.

IMPROVEMENT OF PETALUMA CREEK, CALIFORNIA.

A description of this stream, its original condition, the plan for its improvement and the results obtained are given in the Annual Report of the Chief of Engineers for 1897, page 3365.

Report of operations for the fiscal year ending June 30, 1898.—No work has been done during the fiscal year and no funds expended. While the channel has slightly deteriorated, navigation has in no way been interfered with during the year.

Remarks.—This creek, or, more correctly, tidal estuary, is the water outlet of one of the richest valleys in California, which is in a high

*Indeterminate. † Sufficient on hand.

state of cultivation and produces large quantities of fruit, grain, and other agricultural products. The town of Petaluma has a population of a little over 4,000 and is particularly flourishing, containing as it does several important manufactories, the establishment of which is said to be due in a great measure to the existence of cheap water transportation to San Francisco. The freight rates by rail from all points within one day's haul of Petaluma Creek show the beneficial effects of water competition.

Future operations.—The water of Petaluma Creek brings down annually large quantities of detritus, which are deposited in the channel, and consequently frequent dredging will be necessary.

It is estimated that $4,000 can be advantageously expended on this work during the fiscal year ending June 30, 1900.

Money statement.

July 1, 1897, balance unexpended	$39.49
July 1, 1898, balance unexpended	39.46
Amount (estimated) required for completion of existing project	(*)
Amount that can be profitably expended in fiscal year ending June 30, 1900	4,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations for the improvement of Petaluma Creek, California.

June 14, 1880	$8,000
March 3, 1881	8,000
August 2, 1882	14,000
August 11, 1888	2,000
September 19, 1890	4,000
July 13, 1892	10,000
August 18, 1894	15,000
Total	61,000

COMMERCIAL STATISTICS.

Every effort was made to collect the statistics of commerce on this creek during the past year, but they could not be obtained.

S S 7.

IMPROVEMENT OF HUMBOLDT HARBOR AND BAY, CALIFORNIA.

A description of this bay, its original condition, and the plans for its improvement are given in the Annual Report of the Chief of Engineers for 1896, page 3207.

Report of operations for the fiscal year ending June 30, 1898.—During the year there was expended on this work the sum of $246,780.99.

North Jetty.—No work was done on this jetty during the fiscal year. Profile and cross-sections, however, show that it is in practically the same condition that it was at the end of the last fiscal year, although much of the trestle has been damaged.

* Indeterminate.

South Jetty.—At the commencement of the fiscal year work, which consisted of jetty extension and placing rock in the jetty, was going on. At that time the rock was +10 feet (this means 10 feet above low water) from shore to bent 225, thence sloping from 0 at bent 255, thence to −9 feet at bent 260, thence to −12 feet at bent 320, and thence to about −20 feet at the end, which is 5,451 feet from the shore.

Rough weather delayed the work, especially the trestle building, but by the end of August the trestle had been extended to bent 341, or 752 feet, since the beginning of the fiscal year. It was then stopped for the season, the outer bents having been strengthened to preserve them if possible against destruction by winter storms. The delivery of rock was continued until October 21, when it was discontinued, and, after 40 piles had been driven to strengthen the wharf, work was suspended for the winter. Up to this time 66,436 tons of rock, 60 per cent of which was large, had been placed in the jetty.

The winter of 1897–98 was generally less severe than usual, although a few of the storms were very heavy; the strengthening of the trestle by extra fastenings, however, saved it from much damage. The greatest destruction was done by the two trees which tore out 15 piles.

Work was resumed March 3, 1898, and as the beach had advanced in shore beyond the apron of the wharf, another wharf was built to deeper water, and the apron, incline, and scales moved inward 170 feet. Repairs to the trestle were commenced March 24, and on April 20 trestle extension was commenced. Rock delivery began on April 21.

During this season the brush mattresses have been omitted, and in their place a layer of small rock, 1 pound and upward, has been used. This has been found of great advantage in reducing the amount of scour which occurs between the time of building the trestle and placing the rock, and also in reducing the cost of the jetty. Work was being pushed vigorously at the end of the fiscal year.

At the end of the fiscal year the rock in the jetty was above low water to bent 395, thence sloping down to −18 inches at bent 423, thence sloping gradually to the end, at bent 462.

Up to June 30, 67,755 tons of rock had been placed in the jetty during the present season.

During the fiscal year the contractor delivered 134,191 tons of rock and constructed 1,312 linear feet of trestle with double-track railway.

A complete survey of the entrance to the bay was made in October, 1897, and another in May, 1898. A copy of the latter is sent herewith.

Engineering methods.—The methods are the same as those heretofore used, viz: hauling the rock out on a double-track railway, carried on a trestle, and dumping from this into the sea until the required height of enrockment is obtained. The sea flattens this out, more rock is added, and eventually this gets into a position of equilibrium. The bents of the trestle are 16 feet apart, and some bents now contain over 2,000 tons of rock. To protect the trestle against the violent wave action, extra heavy fastenings above those originally contemplated had to be used.

Remarks.—During the fiscal year the work has been in local charge of Mr. D. E. Hughes, assistant engineer, whose report to the end of the fiscal year is herewith.

Future operations.—The north jetty being practically completed, it is expected to confine operations mainly to the south jetty. The balance now available for continuing the work is $269,857.15. The estimate made by the Board of Engineers in 1891 for the completion of the work was $2,057,615, which is $143,115 less than has thus far been appropriated. It is believed the $143,115 will complete the work as estimated for.

Money statement.

July 1, 1897, balance unexpended		$486,638.14
Amount appropriated by sundry civil act approved July 1, 1898		100,000.00
		586,638.14
June 30, 1898, amount expended during fiscal year		246,780.99
July 1, 1898, balance unexpended		339,857.15
July 1, 1898, outstanding liabilities	$50,000.00	
July 1, 1898, amount covered by uncompleted contracts	289,857.15	
		339,857.15
Amount (estimated) required for completion of existing project		143,115.00
Amount that can be profitably expended in fiscal year ending June 30, 1899		143,115.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Amount and date of all appropriations for improving Humboldt Harbor and Bay, California.

March 3, 1881	$40,000	March 3, 1893	$522,000
August 2, 1882	40,000	March 2, 1895	225,000
July 5, 1884	62,500	June 11, 1896	225,000
August 5, 1886	75,000	June 4, 1897	350,000
August 11, 1888	125,000	July 1, 1898	100,000
September 19, 1890	80,000		
July 13, 1892	150,000	Total	1,994,500

LIST OF ALL CONTRACTS IN FORCE ON ACCOUNT OF IMPROVING HUMBOLDT HARBOR AND BAY, CALIFORNIA.

Contract dated December 16, 1892, for jetty work at the entrance to Humboldt Harbor, California.

Name of contractor.	Date of approval	Work commenced.	Expiration.
John C. Bull, jr.	Dec. 29, 1892	Apr. 15, 1893	This contract is continuous.

Contracts supplemental to above.

Name of contractor.	Date of approval.	
	By Chief of Engineers.	By Secretary of War.
John C. Bull, jr.	Jan. 8, 1897	Jan. 9, 1897
Do	Aug. 21, 1897	Aug. 28, 1897
Do	Jan. 31, 1898	Feb. 3, 1898
Do	May 14, 1898	May 19, 1898
Do	June 6, 1898	June 9, 1898

STATISTICS OF COMMERCE OF HUMBOLDT HARBOR AND BAY, CALIFORNIA.

The following statement of the export trade of Humboldt Bay, California, for the calendar year 1897 was collected and supplied by Mr. George A. Kellogg, secretary of the Humboldt Chamber of Commerce:

Exports.

Articles.	Weight.	Value.
	Tons.	
Lumber	206,006	$1,778,695
Miscellaneous products	10,605	1,411,300
Total	216,611	3,189,995

A correct statement of the imports of Humboldt Bay could not be obtained, owing to the large number of coasting vessels which bring freight into this port.

In the foregoing lumber exports are included the following:

Foreign lumber exports.

Country or seaport.	No. of cargoes.	Net tonnage.	Feet.	Weight.	Value.
				Pounds.	
Australia	12	6,340	5,719,972	18,590,000	$90,858.34
Hawaiian Islands	12	3,249	3,728,575	12,117,875	41,047.33
Mexico	3	752	869,503	2,825,875	11,082.28
Champerico, Central America	1	185	265,991	864,475	2,851.42
Panama, United States of Colombia	1	168	191,362	621,925	2,870.43
Callao, South America	1	299	302,111	981,850	5,185.89
Shanghai, China	1	444	387,033	1,257,850	4,946.95
Total	31	11,432	11,464,547	37,259,850	158,792.64

Movement of vessels, tonnage, and passengers.

	Steam vessels.	Sail vessels.	Total vessels.	Tonnage.	Passengers.
Arrived	435	203	638	240,487	7,160
Departed	433	208	641	241,739	7,582
Total	868	411	1,279	482,226	14,742

The following is a statement of the business done by the Pacific Coast Steamship Company between San Francisco and Humboldt Bay during the calendar year 1897:

Freight	tons..	59,003
Treasure		$593,584
Passengers		9,311

The following is a statement of the business done by the steamer *North Fork* between San Francisco and Humboldt Bay during the same period:

	Received at Humboldt Bay.	Delivered at Humboldt Bay.
Lumber tons..	18,838	.....
Merchandise do....	.....	5,074
Passengers	330	322

Comparative yearly statement of freight of Humboldt Bay, California.

Year.	Passengers.	Freight.	Year.	Passengers.	Freight.
		Tons.			*Tons.*
1885	4,195	162,614	1894	15,201	217,541
1886	4,534	193,607	1895	11,261	185,594
1887	6,610	297,746	1896	11,415	226,378
1892	12,696	522,893	1897	13,252	168,825
1893	14,664	286,719	1898	14,742	216,611

REPORT OF MR. D. E. HUGHES, ASSISTANT ENGINEER.

HUMBOLDT BAY, CALIFORNIA,
June 30, 1898.

MAJOR: I have the honor to submit the following report of operations for the improvement of the entrance to Humboldt Bay, California, during the working season of 1872.

Work of the previous season closed on south spit September 1, 1896, and on north spit April 17, 1897. Lieut. James J. Meyler, Corps of Engineers, U. S. A., in his report for that season, described the condition of the jetties for those dates

reported the damage done the trestle by the sea and the changes in shore lines at south spit during the winter of 1896–97.

The work credited to season of 1897 was done by Mr. John C. Bull, jr., of Arcata, Cal., under contract dated December 16, 1892, and was practically all on south spit. It was begun March 15, 1897. First, a new wharf was built 900 feet south from the old one, and the apron, incline, scales and short tracks moved to the new location. On April 10 renewal of the shore-protection trestle and repairs to the jetty trestle were begun. April 19 rock delivery began. Nine thousand three hundred and eighty-two tons of large rock (pieces of 2,240 pounds and upward), and 7,463 tons of small rock (50 pounds to 2,240 pounds) were placed on the 1,200 feet of shore protection, most of the small on the land side of the single track and the large on the other, building it to an elevation of about 16 feet. (The datum is mean lower low water.) For about half the length this rock rests on the old brush and rock foundations. The rest of the way it rests directly on the sand and clay, 2 or 3 feet above low water. This wok was completed May 17, 1897. No change has occurred in it since.

By this time repairs to jetty trestle, made necessary by decay, toredo, and the sea, were about completed to bent 244, the last bent then standing, and rock work was transferred to the jetty, beginning at bent 145, to replace rock that had been knocked off by the sea. (Bents are 16 feet apart, and numbered consecutively from shore.)

Rebuilding the trestle from bent 244 to bent 341 on the mound of rock, where more than half the time the sea was too rough for pile driving, was not completed till August 14. Although a narrow mound of small rock free of sand makes easy driving, here, near the south edge of a very wide mound containing some large rock and having sand between the rock and south of it, generally level with the top, the resistance was great. Pile shoes were used of ¼-inch steel plate, made into a frustrum of a cone, having diameters of 5 inches and 12 inches and a slant height of 13 inches. These proved very satisfactory. An average penetration of 9 feet was secured and only a few piles were crushed.

The trestle fastenings used by the contractor were like those of 1896, with the addition of wrought-iron washers ⅜ by 2½ by 3 inches, under heads and nuts of screw bolts. The only trestle lost during the working season was bent 312, carried away July 15. During August and September the outer 100 bents, from 241 to 341, were strengthened by the Government. To each pile fastening a 1 by 36 inch drift-bolt was added, and ¾-inch screw bolts were placed horizontally through each end of every stringer and cap. Long round timbers were placed on each side, like those described by Lieutenant Meyler in Report for 1896. To help the outer end withstand the heavier southwest seas, 5 long well-shod piles, with 1¼-inch galvanized steel cables attached 10 to 15 feet above the lower end, were driven 15 to 20 feet opposite each tenth bent, 27 feet south of center of trestle, and broken off even with the sand and rock. The cables, with gas pipes strung on to prevent chafing by rock placed later, were drawn about 45 degrees upward to the north side of the trestle and there secured to the round timbers and caps.

While the trestle was building, and in advance of the rock trains, many cross sections 160 feet wide were taken from the sounding car to determine the outlines of the old enrockment. Beyond bent 231 it was found remarkably smooth on top, adjacent soundings on rock, 5 feet apart on the nearly level crest, 80 to 100 feet wide, rarely varying more than half a foot. The profile shows that from bent 145 to 198 the rock had been beaten down a little in places. From 198 to 220 it sloped from +5 feet to 0; 220 to 231, from 0 to —8 feet; then, with variations of less than a foot, the height from bent 231 to 245 was —8 feet; 245 to 280, —10 feet; 280 to 300. —11 feet; 300 to 310, —12½ feet; 310 to 332, —13 feet; 332 to 335, —11 feet, and from 335 to 341 it sloped from —11 feet down to —19 feet. Shoreward from bent 145 and seaward from 334 the profile had not changed since September, 1896. The cross sections show that the rock had been driven mostly to the north side and to some extent shoreward along the jetty. But their areas taken together account for all the rock placed there, and show that it was neither driven away from the line of the jetty nor had settled into the sand, although brush supports less than half of it. This small rock on the north side is not more than is probably necessary to guard against undermining by the channel, which in future will most likely continue to hug this jetty.

During 1897 62,265 tons of large rock and 31,416 tons of small rock were placed on the south jetty. About 5,000 tons were placed between bents 145 and 200; the rest from 200 to 341. About 10,000 tons of the small rock were used on the outer part of the jetty to build the small-rock foundation up to —9 or —10 feet, and the rest was mixed with the large, generally at the rate of one car of small rock to three cars of large. Ahead of bent 240 the rock was dumped on both sides of both tracks. This plan reduced breakage without increasing the ultimate width. In many bents rock along the center piled up to +10 feet and higher, but the seas soon knocked it down. Later in the season the profile was disregarded, and the rock was located to make the amounts above —10 feet in the different bents approximately equal.

Rock delivery ceased and work on south spit closed for the season October 21. During the rest of the month 40 piles were driven at north spit to hold the wharf and apron through the winter for possible use in the spring.

Profile and cross sections were taken of north jetty in May, 1897. The jetty is now in practically the same condition. It rises above high water from shore to bent 150; thence above half tide to bent 300; thence above low water to bent 460; thence slopes down to —10 or —11 feet at the end, or bent 500, which is 8,060 feet from shore. Its trestle is standing to bent 454, except a gap from 417 to 429. A great many piles are gone and many more are practically destroyed by toredo.

Profile and cross sections of south jetty were taken again in the fall. During September, October, and November the enrockment was beaten down considerably beyond bent 200 and a little here and there into bent 120. In December—and there has been little change since then—the jetty was above high water from shore to bent 200; thence at half tide to bent 230; thence between half tide and low water to bent 310; thence 1 foot below zero or low water to bent 325; thence it sloped down to —10 feet at the end, or bent 341, which is 5,460 feet from shore. Beyond bent 310 the profile had suffered little change since the last rock was placed there.

In May and again in October complete surveys were made of the bar, entrance, and the adjacent portions of the two bays, and in August a survey confined to the channels. The least depth on the best course over the bar at mean low water was 22 feet in May, 24 feet in August, and 21 feet in October. Doubtless the depths were less during and just after times of very rough bar. It has often been too rough to cross, but at no time for several years past have vessels been detained for want of water.

The winter of 1897-98 was not so rough as common, and a shoal seaward from south jetty grew up to —11 feet, affording the jetty more protection against the southwest seas; yet two or three times before Christmas, along the outer portion of south jetty, there were worse seas than any that have been successfully resisted by the trestles here before. No damage was done the trestle by the sea, except that many foot plank were knocked off and one of the 1¼-inch cables was broken. I am quite sure, however, that in other winters I have seen much greater breakers in the same locality. Two large trees drifted through the trestle from the south. One broke out 5 piles near bent 210, the other 10 piles near bent 268. No other damage was done.

Of the rock delivered during the season about 86,700 tons was from the old quarry; 11,500 tons, nearly all large, was from The Falls, and 12,300 tons, mostly large, from The Pinnacle. Nearly all of the old quarry rock disintegrates more or less under atmospheric pressure alone, and apparently more rapidly near the sea than at the quarry; but a wetting, even only once a day, preserves it, and water increases its hardness both at the quarry and in the jetties. Its average weight is 160 pounds per cubic foot. It seems quite firm, yet it breaks considerably when falling from the high trestle onto rocks that are above water. A lower trestle would reduce the breakage, but here the exposure makes necessary the higher structure. The Falls rock, exhausted in August, weighed 180 pounds, was much harder, and broke but little. Pinnacle rock, first quarried in July, weighs 180 pounds, is very hard, and rarely breaks at all in dumping. After the enrockment got above water in the center it was the practice to dump most of the stronger rock between the tracks and much of the other outside, where there was still at times a water cushion to reduce the breakage. The large rock averaged about 2 tons. About 16 per cent of it was over 4 tons. The maximum was 8 tons.

The following are the items of work done by the contractor during the season:

Large rock delivered	tons..	71,646 1740/2240
Small rock delivered	do....	38,897 478/2240
Trestle constructed (approach to apron)	linear feet..	282 8/10
Piles driven for repairs	number..	715
Caps placed	linear feet..	5,541 8/10
Stringers placed	do....	9,401 8/10
Rails laid	do....	8,872 8/10
Extra labor amounted to		$1,655.20
The total earnings of the contractor for the season were		$176,053.14

During January, 1898, the beach at south spit wharf advanced beyond the apron. In February a row of sheet piling was driven to train a slough against it. Later more sand came than the trained slough could handle, and again the beach grew out, this time beyond the wharf.

The contractor began work on March 3. Another wharf was built farther out, and the apron, incline, and scales moved forward 170 feet, and the pile and timber track north of the scales extended 160 feet. Repairs to south jetty trestle were begun March 24. The 15 piles that had been broken out by floating trees, and many more destroyed by toredo, were replaced. Some of the piles that had supported rock trams in October fell over when released from their caps. About 140 scattering

piles were tested with the pile-driver hammer; many of them failed. In addition, a heavy rolling load test was applied. It appearing that the trestle could be used for a short time with reasonable safety further repairs were temporarily deferred, in order that jetty extension might not be delayed, and the driver was moved to the front. A cross-over track was built, extending from bent 328, on the north track, to bent 337, on the south; and just shoreward from it was constructed a turn-out that would hold the pile driver over the south half of the trestle and leave the north track clear.

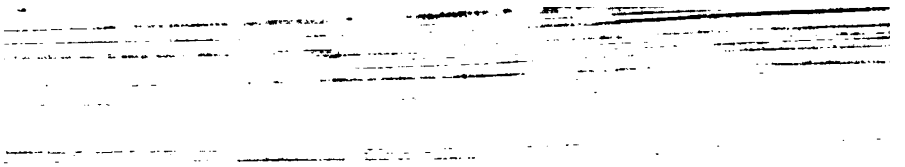
Trestle extension began at bent 341 April 20, and rock delivery April 21. At a few of the first bents driven the low-water depth was 29 feet, due to a flood-tide channel that had just opened along the beach. Here the flood current was so strong that piles when dropped would foul in the leaders and not reach bottom, and driving had to be confined to ebb tide and slack water. It was too rough for pile driving so much of the time that, although all daylight hours, Sundays included, when the sea was smooth enough, had been utilized, only 13 bents of trestle were constructed in April and 27 in May. Whenever it was too rough for trestle building, and at first oftener, the driver was taken back to the turn-out, and, to prevent scour between the piles, a thin layer of foundation rock (1 pound and upward) was dumped from both tracks out to and around the end bent. During June the trestle was extended from bent 381 to bent 423, which is 6,773 feet from shore.

The trestle has 4-pile bents, 16 feet apart. The piles, with bark off, are 12 inches to 18 inches in diameter at the smaller end. They are driven about 8 feet apart to a penetration of 15 feet with a 2-ton hammer, requiring anywhere from 100 to 200 blows, averaging about 12 feet. They are sawed off about 25 feet above low water, and rings of ⅜ by 2½ inch iron, 16 inches to 18 inches diameter, are driven into the heads by the pile-driver hammer. The 12 by 12 inch by 32 foot caps are screwed to each pile by one ⅞ by 24 inch driftbolt, one 1 by 28 inch screw bolt having its nut in a 3½-inch hole bored horizontally into the pile, and one 1 by 36-inch headed driftbolt. The four 12 by 14 inch by 32 foot stringers, spread for double track of standard gauge and 15 feet between centers, are secured to the caps by 1 by 28 inch screw bolts. Round timbers, 64 feet long and over 12 inches in diameter at the smaller end, are placed on each side just outside the other stringers, breaking joints with each other and with the stringers alongside. They are notched from 3 to 8 inches deep to fit down over the caps closely, and are bolted to them with 1-inch screw bolts. They are also bolted near each end to the stringer. One ⅞ by 14 inch screw bolt is placed horizontally through each end of every stringer and cap. Wrought-iron washers ⅜ by 2½ by 2½ inches are placed under heads and nuts of all bolts. The steel rails, 40 pounds per yard, are spiked directly to the stringers. Foot planks 2 by 12 by 4½ inches, 14 to each bent, are spiked to the stringers between the rails. All piles and timbers are Douglas spruce. To steady the trestle while enrockment was low, many 1⅛ and 1¼ inch wire cables were placed diagonally from outside piles close to the sand to the opposite ends of the caps. Now, beginning with bent 400, more substantial ties are placed 4 or 5 bents apart, consisting of 1¼-inch round-iron eyebars attached to outside piles, 10 to 12 feet below low water, by 1¼-inch chains, and to the round timbers and caps on the opposite side of the trestle by 1¼-inch wire rope. Most of the diagonal ties are set to resist the heavier southwest seas, which come to the jetty from nearly west. It takes three hours to build a bent, or 16 feet of trestle. So far this season no damage has been done to the trestle, though it was considerably distorted in places before all the extra fastenings were put on.

Brush mattresses are omitted this season, and a layer of foundation rock, in pieces of 1 pound and upward, at a reduced price, is used instead. This change greatly facilitates the work. It had been definitely determined that, under the conditions existing here, brush served no useful purpose.

The experiment at spur 127, south jetty, where in 1895 a gap of 96 feet was left in the mattress foundation, has been reported on by Lieut. Herbert Deakyne and by Lieut. James J. Meyler. Because of the importance of the subject, more of the details are here given. This 96 feet of enrockment on sand rests in depths varying from 12 to 21 feet, in a locality where neither the seas nor the currents are very strong. Many soundings were taken from time to time off the sounding car, and no appreciable settlement was discovered. Besides, the areas of the cross sections tallied with those that the known amounts of rock dumped there should give, showing that while the enrockment was building, as well as later, no appreciable amount of it had sunk into the sand. Like investigations, when applied to either side where there were mattresses as wide as the rock, showed that the brush had been compressed by the 6 to 8 feet of rock upon it to not more than one-third of the volume paid for, making its cost (at the prices here) greatly exceed that of an equal volume of rock.

A more instructive example bearing on the same question is found at bent 231, south jetty, where the current was strong and the seas violent, and where the enrockment is 30 feet high and over 100 feet wide. Seaward from this point, in 1895,



mattresses 52 feet wide and 3 feet thick were sunk in 24 feet of water. For several bents shoreward from 231 the small rock of 50 pounds and upwards was dumped on the sand in depths of 25 feet, and the jetty there is without the influence of brush. The cross sections taken from time to time off the sounding car show that for a considerable length on either side of 231 the exposure did not vary, and that the depths alongside were practically the same and underwent like changes, increasing from 24 and 25 feet to a depth of 40 feet on the channel side and shoaling to zero on the other. From the records kept here the amount of rock in each bent was determined, and it was found that in the first four bents seaward from 231 a little more rock had been placed with the brush to build the jetty from — 24 feet to + 1 foot than had been used on sand in the first four bents shoreward of 231 to raise the wall from — 25 feet to + 1½ feet. Cross section at 230 accounted for all the rock that had been placed there (at the rate of 22 cubic feet to the ton). Just ahead on the brush it failed to do so, even when the volume of the mattress was disregarded entirely, thus apparently necessitating the theory that in a current the edge of a mattress, before the enrockment gets wide enough to reach beyond it, provokes more scour alongside and underneath than is caused by a sloping toe of small rock. Unfortunately, no cross sections were taken at the proper time to verify this. There are other evidences on this work, however, showing that at times a considerable cave has been formed under the edge of a mattress before the enrockment could be made sufficient to break it down and go beyond it.

Another saving effected by the omission of the mattresses, especially in strong currents, is in the reduction of scour provoked by the presence of piles, which in a rough sea must often stand for several days before mattresses can be placed around them. This scour in the past sometimes became excessive, reaching 9 feet at bent 290, south jetty, in 1896, and over 12 feet in 1893 at bent 95 of north jetty. This season, by keeping a thin layer of foundation rock well to the front, a stronger current was crossed and the scour kept below 2 feet. At times, by dumping rock first from the north track, a deposit of sand was gained under the other. We are also saved the considerable risk to both life and property which attends the sinking of large mattresses in a rough sea. On this work, at times, mattresses have been sunk between seas when a delay of 10 seconds after the operation began would have proved fatal to the men employed.

Of the rock received this season a small amount was placed on the old work from bent 310 to 341, building it up to about low water. The rest has been placed on the new work, in depths that were between 16 and 20 feet, except between bents 341 and 351, where the maximum was 30 feet. This rock is now above low water to bent 395, thence slopes down to — 18 feet at bent 423; but the wall is narrow and contains less than half the rock that will be required there. It is the plan, barring accidents, to follow the driver closely until the end is reached (about bent 462), finish the enrockment there, and then work shoreward. The monthly rock delivery for June, 36,337 tons, is the greatest that has ever been handled on this work. The usual complete survey was made in May and a map thereof sent to your office. It shows a 23-foot channel over the bar, and good water leading into both bays.

The following are the items of contract work done here during the present season, up to the end of June, 1898:

Large rock delivered	tons..	22,462$\frac{990}{2240}$
Small rock delivered	do....	34,242$\frac{910}{2240}$
Foundation rock delivered	do....	11,051$\frac{910}{2240}$
Trestle, with double-track railway thereon	linear feet..	1,312
Single track on trestle	do....	196$\frac{8}{10}$
Piles driven	number..	232
Caps placed	linear feet..	446
Stringers placed	do....	660
Rails laid	do....	660
Extra labor amounted to		$1,543.92
Contractor's earnings amounted to		$100,818.46

The following are the items of work done by the contractor during the fiscal year ending June 30, 1898:

Large rock delivered	tons..	65,221$\frac{1440}{2240}$
Small rock delivered	do....	57,919$\frac{990}{2240}$
Foundation rock delivered	do....	11,051$\frac{910}{2240}$
Trestle, with double-track railway thereon	linear feet..	1,312
Single track on trestle	do....	196$\frac{8}{10}$
Piles driven	number..	460
Caps placed	linear feet..	1,950
Stringers placed	do....	3,678$\frac{8}{10}$
Rails laid	do....	3,678$\frac{8}{10}$
Extra labor amounted to		$[illegible]

In concluding this report I desire to commend the contractor's representatives for prosecuting the work so vigorously, and particularly for their evident desire to do what is right.

To Mr. Floyd Moulton, who has been inspector on the work since March, 1893, special acknowledgments are due for long hours of service rendered with fidelity, accuracy, and dispatch.

I also have the pleasure to express my gratitude to the officers in charge, whose will I have tried to execute, for their unvarying courtesies and kindness.

D. E. HUGHES,
Assistant Engineer.

Maj. W. H. HEUER,
Corps of Engineers, U. S. A.

ESTIMATE OF COST OF IMPROVEMENT OF HUMBOLDT HARBOR, CALIFORNIA, BY DREDGING.

[Printed in House Doc. No. 528, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, June 8, 1898.

SIR: By joint resolution of Congress approved May 7, 1898, the Secretary of War is requested to submit detailed estimates, from information now on file, of the cost of the proposed dredging and improvement of Humboldt Harbor, California, as contemplated by the river and harbor act of June 3, 1896, and by the report of Capt. Cassius E. Gillette, Corps of Engineers, submitted to Congress in the Report of the Chief of Engineers.

The river and harbor act of June 3, 1896, provided for a preliminary examination of Humboldt Harbor, California, dredging same along city front, and the report of Captain Gillette of the results of this examination was submitted to Congress in the Annual Report of the Chief of Engineers for 1897.

In 1881 a project for improving the inside harbor at Humboldt was adopted with a view to securing, by dredging, a channel 12 feet deep and 200 feet wide to the head of Eureka wharves and 10 feet deep and 100 feet wide to Arcata and Hookton. This project was completed in 1884, but the channels have since silted up materially, and the improvement now proposed for this locality contemplates redredging a channel 200 feet in bottom width, about 8,900 feet in length, to a uniform depth of 15 feet below water surface at mean low-tide level. This will require the excavation of about 370,384 cubic yards of material, principally sand, mud, and shells, and to remove this material and deposit the same on the shores of the bay above the reach of tidal influence will, it is estimated, cost 20 cents per cubic yard, or, say, in round numbers, $75,000.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

APPENDIX T T.

IMPROVEMENT OF RIVERS AND HARBORS IN OREGON, OF UPPER COLUMBIA RIVER AND TRIBUTARIES, OREGON AND WASHINGTON, AND OF CLEARWATER RIVER, IDAHO.

REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS. OFFICERS IN CHARGE, LIEUT. COL. CHARLES L. POTTER, U. S. VOLUNTEERS, CAPTAIN, CORPS OF ENGINEERS, AND MAJ. W. L. FISK, CORPS OF ENGINEERS.

IMPROVEMENTS.

1. Port Orford Harbor, Oregon.
2. Coquille River, Oregon.
3. Coquille River, Oregon, between Coquille and Myrtle Point.
4. Entrance to Coos Bay and Harbor, Oregon.
5. Harbor at Coos Bay, Oregon.
6. Coos River, Oregon.
7. Umpqua River, Oregon.
8. Mouth of Siuslaw River, Oregon.
9. Alsea River, Oregon.
10. Yaquina Bay, Oregon.
11. Nestugga River, Oregon.
12. Tillamook Bay and Bar, Oregon.
13. Upper Columbia and Snake rivers, Oregon and Washington.
14. Columbia River at Three Mile Rapids, and boat railway from The Dalles Rapids to Celilo Falls.
15. Canal at the Cascades, Columbia River, Oregon.
16. Operating and care of canal and locks at the Cascades, Columbia River.
17. Columbia River between Vancouver, Washington, and mouth of Willamette River.
18. Clearwater River, Idaho.

EXAMINATIONS.

19. Umpqua River, bar and entrance, Oregon.
20. Alsea River, Oregon.
21. Yaquina River, including Big Elk River to Sunset Quarry, Oregon.
22. Siletz River, Oregon.
23. Harbor at Cape Lookout, Oregon.

SURVEYS.

24. Port Orford Harbor, Oregon.
25. Tillamook Bay, bar and entrance, Oregon.
26. Nehalem River (bay), Oregon.
27. Snake River, Washington.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., August 3, 1898.

GENERAL: I have the honor to submit herewith annual reports of operations for the fiscal year ending June 30, 1898, for the river and harbor improvements in my charge, temporarily, since May 11, 1898. This district, with the exception of Upper Columbia and Snake rivers, Oregon and Washington, and Clearwater River, Idaho, was in my charge until November 30, 1897; Upper Columbia and Snake rivers and Clearwater River were in charge of Capt. Harry Taylor, Corps of

Engineers, until November 30, 1897. From November 30, 1897, to May 11, 1898, the district was in charge of First Lieut. Charles L. Potter, Corps of Engineers, and since May 11, 1898, it has been in my charge, temporarily.

Very respectfully, your obedient servant,

W. L. FISK,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

T T 1.

IMPROVEMENT OF PORT ORFORD HARBOR, OREGON.

The river and harbor act of June 3, 1896, contained the following item:

Improving Port Orford Harbor, at Graveyard Point, Oregon, according to plan recommended by Captain Thomas W. Symons, of the Corps of Engineers, as per House Document Numbered Three hundred and thirteen, Fifty-third Congress, third session, January thirtieth, eighteen hundred and ninety-five, to cost not to exceed two hundred and three thousand three hundred and thirty-six dollars; and the unexpended balance of the appropriation heretofore made March third, eighteen hundred and seventy-nine, for the establishment of a harbor of refuge on the Pacific coast, is hereby transferred to be expended on this improvement, if in the opinion of the Secretary of War the interests of commerce demand such expenditure.

The report to which reference in the above-quoted item is made is printed in the Annual Report of the Chief of Engineers for 1895, Part V, pages 3491–3501, and contained an estimate of $203,366 for constructing a wharf from Graveyard Point for commercial shipping purposes.

Nothing has been done toward the construction of the proposed wharf, as the Secretary of War has not decided that "the interests of commerce demand such expenditure."

The river and harbor act of June 3, 1896, also provided "for a survey of Port Orford Harbor, Oregon, with estimate of cost of improvement and importance to shipping and commerce." The report of the survey is herewith.

Money statement.

July 1, 1897, balance unexpended	$140,858.52
July 1, 1898, balance unexpended	140,858.52
Amount (estimated) required for completion of existing project	62,477.48
Submitted in compliance with requirements of section 2 of river and harbor act of 1866.	

T T 2.

IMPROVEMENT OF COQUILLE RIVER, OREGON.

GENERAL IMPROVEMENT.

The original and modified projects and estimates of cost (printed in the Annual Reports of the Chief of Engineers for 1879, Part II, p. 1806, and for 1892, Part III, pp. 2662–2665) for improvement at the mouth of the Coquille River provide for the construction of two high-tide rubble-stone jetties 600 feet apart at their outer ends, to confine and control

the flow of the waters so as to permanently close up the original tortuous shoal and shifting channel, which skirted the south headland, and scour a channel through the sand spit on the north side of the entrance, the jetties to extend out to sea a sufficient distance to maintain a channel over the bar with the least depth of 8 feet at low tide, at an estimated cost of $285,000, including $6,883.90 expended under the acts of Congress of August 11, 1888, and September 19, 1890, in removing snags between Coquille and Myrtle Point.

The method of constructing the jetties at the mouth of the Coquille River has consisted of building a tramway resting on piles driven along the line of each proposed jetty, upon which is hauled, in dump cars pulled by a small locomotive, the loose stone to be dumped in place in the jetty.

SOUTH JETTY.

In May, 1897, this jetty was 2,116½ feet in length, and had been brought up to high-tide level throughout that distance.

A contract was entered into on December 26, 1896, with Daniel Kern, of Portland, Oreg., which provided that the contractor should furnish all the labor and materials necessary to extend the south jetty as far as practicable with the available funds, by building a double-track tramway in extension of the existing tramway, by laying a brush-mattress foundation throughout the length of such extension, and dumping thereon the enrockment of the jetty. It also provided that the Government plant used on the work in past years, consisting of 1 locomotive, 1 pile driver, 2 hoisting engines, 2 derricks, 12 dumping cars, and sundry tools and appliances, should be turned over to the contractor for use in carrying on the work, for which use he should pay the sum of $150 per month.

The contractor began operations in May, 1897, and between then and November 28, 1897, when operations were suspended, furnished in place along the jetty the following-named quantities of materials, at the prices named in the abstract of his proposal printed in the Annual Report of the Chief of Engineers for 1897 (p. 3382):

Extending tramway:		
Piles	linear feet..	2,491.66
Lumber	feet B. M..	23,590
Driftbolts	pounds..	1,006
Bolts with nuts and washers	do....	160
Wrought spikes	do....	214
Railroad spikes	do....	280
Extending jetty, stone	tons..	30,105

Under this contract the tramway and jetty were extended 270½ feet, giving the jetty a total length of 2,387 feet. The jetty is up to high-tide level throughout that distance.

The piles used in extending the tramway were fir. It was impossible to drive them beyond an average penetration of about 4 feet, as they soon brought up on the hard bed rock underlying the sand. On account of the proximity of this underlying ledge the brush-mattress foundation required by the contract for the extension of the jetty was dispensed with.

The contractor used one derrick in taking the stone from the quarry at Tupper Rock (a portion of which latter is owned by the United States). This stone was placed in the jetty as it came from the quarry—in pieces weighing from about 50 pounds each up to about 12 tons each. The quarry is directly connected with the jetty by a short tramway, and the average delivery of stone was 200 tons per day.

NORTH JETTY.

No work was done during the past fiscal year on this jetty, which, in previous years, had been constructed for the distance of 510 feet. The tramway is in such condition that it will probably be necessary to rebuild it before it can be used. The outer 300 feet of the jetty itself has settled considerably.

The coarse sand has accumulated on the south side of the south jetty so that the low-water line is at present nearly as far out as the sea end. The bar channel runs straight out to sea parallel to the south jetty; its average depth at mean lower low water during the past year was about 7 feet. The depth on the bar has not been materially increased during the year, and no substantial improvement is anticipated in advance of the extension of the north jetty.

Money statement.

July 1, 1897, balance unexpended	$21,000.84
June 30, 1898, amount expended during fiscal year	19,420.73
July 1, 1898, balance unexpended	1,580.11
July 1, 1898, outstanding liabilities	68.20
July 1, 1898, balance available	1,511.91
Amount (estimated) required for completion of existing project	115,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	115,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—		Act of—	
June 14, 1880	$10,000	July 13, 1892	$25,000
August 2, 1882	10,000	August 18, 1894	20,000
July 5, 1884	10,000	June 3, 1896	20,000
August 5, 1886	20,000		
August 11, 1888 *	25,000	Total	170,000
September 19, 1890 †	30,000		

Abstract of contract in force during fiscal year ending June 30, 1898, for extending the south jetty at mouth of Coquille River, Oregon.

Contractor.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Daniel Kern	Dec. 26, 1896	Jan. 7, 1897	May 1, 1897	Dec. 31, 1897

COMMERCIAL STATISTICS.

The Coquille River is in the collection district of southern Oregon. Empire City, on Coos Bay, is the port of entry. The nearest light-house is at Rackcliffe Rock, on the north side of the entrance.

*Five thousand dollars of this appropriation were allotted for removing snags between Coquille and Myrtle Point.

†Not to exceed $3,000 of this appropriation were to be expended for removal of snags between Coquille and Myrtle Point.

The following statistics are for the calendar year 1897:

Receipts and shipments.

Articles.	Tons.	Articles.	Tons.
RECEIPTS.		SHIPMENTS—continued.	
General merchandise	3,219	Match wood	589
Wool	92	Broom handles	417
Machinery	21	Salmon	181
Hay	89	Wool and woolen goods	51
		Hides	2
Total	3,421	Agricultural products	32
		Live stock	234
SHIPMENTS.		Miscellaneous	63
Lumber and logs	12,751	Total	23,199
Coal	7,929		

Arrivals and departures of vessels.

Coasting vessels.	Number.	Aggregate tonnage.
Arrivals	95	12,177
Departures	93	12,242
Total	188	24,419

Classification of vessels: Schooners, 62; steamers, 27; tugs, 6.

T T 3.

IMPROVEMENT OF COQUILLE RIVER, OREGON, BETWEEN COQUILLE AND MYRTLE POINT.

The project for the improvement of the Coquille River in the 13 miles between Coquille and Myrtle Point, adopted in 1892, and the revised estimate of cost (reports printed in the Annual Reports of the Chief of Engineers for 1891, Part V, pp. 3280–3283, and for 1895, Part V, pp. 3350, 3351) provide for obtaining a channel 4 feet deep at mean low water and 50 feet wide, so that small steamers may ply between Coquille and Myrtle Point at all times, by removing snags and débris, and by constructing wing dams, pile dikes, and shore protection where necessary to confine and control the waters, at an estimated cost of $50,980.77, exclusive of $6,883.90 expended in removing snags as authorized by the acts of Congress of August 11, 1888, and September 19, 1890.

Up to June 30, 1897, many snags had been removed, and wing dams had been built at Roberts Landing and at Rackcliffe Bar, about 2 miles below Myrtle Point, effecting a partial improvement.

On May 1, 1897, a contract was entered into with Noble & Saunders, of Marshfield, Oreg., for removing the snags that had come into the stream since it was last cleared out, for constructing dikes and shore protection, and for dredging shoals. (See abstract of their proposal, p. 3384 of the Annual Report of the Chief of Engineers for 1897.) The contractors began active operations on June 18, 1897, at which time sections of the river above Coquille were almost impassable at low tide on account of snags; 37 days were devoted to removing these with a steam snag scow and a crew of 8 men.

On account of the limited sum available, the construction of dikes and shore protection and the work of dredging shoals was confined to that portion of the river between Roberts Landing and Rackcliffe Landing, a distance of five-eighths of a mile; 3,700 linear feet of pile and brush dikes, and 2,200 linear feet of pile, brush, and lumber shore protection were constructed, and a channel 50 feet wide and 4 feet deep was excavated through gravel shoals. The contractors had no dredge, but used their pile driver and wheel scrapers and deposited the excavated material behind the dike and shore protection. The following is a summary of the materials furnished and work performed by the contractors, together with the approximate cost of same:

Removing snags.

Snag scow and crew, 37 days, at $25 per day	$925.00	
Powder, caps, and fuse	94.50	
		$1,019.50
Constructing 5,900 linear feet of dike and shore protection:		
Piling, 34,238 linear feet, at 12½ cents per foot	4,279.75	
Lumber, 53,000 feet B. M., at $12.50 per 1,000 feet	662.50	
Spikes, 4,500 pounds, at 7½ cents per pound	337.50	
Wire, 3,200 pounds (No. 12), at 7½ cents per pound	240.00	
Brush, 1,958 cords, at $2.25 per cord	4,405.50	
Sand bags, filled, 9,062, at 12 cents each	1,087.44	
		11,012.69
Dredging shoals: Excavating 2,402 cubic yards gravel, at 15 cents per cubic yard		360.30
Total amount paid contractors		12,392.49
Approximate cost per linear foot of dike		2.20
Approximate cost per linear foot of shore protection		1.30

When the contractors began work, on June 18, 1897, sections of the river above Coquille were almost impassable at low tide, because of the many snags that had accumulated. At the close of operations on October 12, 1897, the river steamers experienced no difficulty in running upstream as far as Roberts Landing. Small bars have since formed, however, which prevent the steamers from navigating the stream above Norway, 3 miles below Myrtle Point, excepting when the stage of water is high.

Money statement.

July 1, 1897, balance unexpended	$13,440.36
June 30, 1898, amount expended during fiscal year	13,279.91
July 1, 1898, balance unexpended	160.45
July 1, 1898, outstanding liabilities	3.20
July 1, 1898, balance available	157.25
Amount (estimated) required for completion of existing project	28,980.77
Amount that can be profitably expended in fiscal year ending June 30, 1900	28,980.77
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
July 13, 1892	$5,000
August 18, 1894	5,000
June 3, 1896	12,000
Total	22,000

Abstract of contract in force during fiscal year ending June 30, 1898, for dredging, constructing dikes, etc., in Coquille River, Oregon, between Coquille and Myrtle Point.

Contractors.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Noble & Saunders	May 1, 1897	May 28, 1897	June 1, 1897	Dec. 1, 1897

COMMERCIAL STATISTICS.

The traffic on the Coquille River between Coquille and Myrtle Point during the year ending December 31, 1897, was handled by the steamers *Cumtux*, of 2.25 tons capacity; the *Myrl*, of 7.43 tons capacity, and the *Ralph*, of 10 tons capacity, the freight carried being as follows:

Articles.	Up.	Down.
	Tons.	*Tons.*
General merchandise, machinery, etc	1,215	.....
Butter and cheese	.....	400
Bacon	.....	30
Live hogs	.....	65
Apples and potatoes	.....	360
Oats and barley	.....	300
Hay	.....	400
Milk	.....	1,250
Total	1,215	2,805

Passengers, up and down, 4,200.

T T 4.

IMPROVEMENT OF ENTRANCE TO COOS BAY AND HARBOR, OREGON.

The original project for improvement, approved November 24, 1879, provided for constructing the jetty described in the Annual Report of the Chief of Engineers for 1880, Part III, page 2323 (and shown also to the right on the chart opposite page 2264 of the Annual Report of the Chief of Engineers for 1884, Part III), to scour the southerly end of the north sand spit to prevent contraction of the channel at the entrance to the bay opposite Coos Head. The estimated cost of the improvement was $600,000. The project was abandoned, however, after the jetty had been built for the distance of about 1,760 feet, at a cost of $213,750, on account of the adoption of the present project.

The present approved project (report of Board of Engineer Officers printed in the Annual Report of the Chief of Engineers for 1890, pp. 2936–2965) provides for constructing two high-tide rubblestone jetties to obtain and maintain at the entrance to the bay a low-water bar depth of at least 20 feet, the north jetty to be 9,600 feet long and the south jetty 4,200 feet long, both to be located as shown on the chart opposite page 3162 of the Annual Report of the Chief of Engineers for 1891, Part V. It also provides for reclaiming and holding the sands of the north spit to prevent them from being blown into the channel. The estimated cost of the present project is $2,466,412.20, independent of the $213,750 expended on the original project.

All operations have been confined to the north jetty. The method of constructing it has consisted of building a tramway resting on piles driven along the line of the proposed jetty, upon which is hauled in dump cars the loose stone, etc., to be dumped in place in the jetty.

Several acres of the north spit have been planted in past years with various grasses, etc., with the view of obtaining definite information with reference to the probability of success in efforts to reclaim the sands of the spit. The experiments made in this direction have demonstrated that the Holland grass (*Arundo arenaria*) can be employed for the purpose with more or less success.

NORTH JETTY.

Up to June 30, 1897, the jetty had been partially built throughout its entire projected length of 9,600 feet, and the work in progress at that date consisted of placing additional rock on the jetty under a contract with Wakefield & Jacobsen, dated October 30, 1896, at 52½ cents per ton.

During the past fiscal year 4,528 feet of the jetty were brought up to high-tide level under the contract with Wakefield & Jacobsen, the contractors having placed in that time 67,728$\frac{7}{10}$ tons of stone (or 158,646$\frac{1}{10}$ all told, from the time that they began operations under the contract in December, 1896, until work was suspended in November, 1897).

The stone used was taken by the contractors from the Government quarry on the North Fork of Coos River, 21 miles from the north spit.

The contractors transported the stone in scows carrying about 280 tons each. The scows were towed from the quarry to the north spit by small steamboats, where a crew of 13 men, with one derrick and one locomotive, unloaded the stone and dumped it on the jetty. The stone is a soft gray sandstone with a specific gravity of 2.35. The contract required that one-fourth of each scow load of stone should consist of blocks weighing at least 4 tons and not exceeding 10 tons each, one-half of blocks averaging 2 tons each, and one-fourth of blocks weighing not less than 400 pounds each, the blocks to be angular and as nearly cubical as possible.

The contractors paid a monthly rental of $500 for the use of the Government plant at the site of the jetty, but furnished their own plant at the quarry.

The majority of the stone furnished under this contract was placed along the outer half of the jetty.

During the past year the channel over the bar had a depth ranging from 18 to 22 feet at mean lower low water. During the past fall the channel was well south of the jetty, but it has since moved gradually back to its normal position nearly parallel to the line of the jetty.

The greater part of the tramway is nearly eight years old, and will require extensive repairs before it can be again used. The same is true with respect to the plant.

Money statement.

July 1, 1897, balance unexpended	$59,723.63
June 30, 1898, amount expended during fiscal year	48,731.49
July 1, 1898, balance unexpended	10,992.14
July 1, 1898, outstanding liabilities	65.00
July 1, 1898, balance available	10,927.14
Amount (estimated) required for completion of existing project	1,941,412.90
Amount that can be profitably expended in fiscal year ending June 30, 1900	600,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—		Act of—	
March 3, 1879	$40,000	September 19, 1890	$125,000
March 3, 1881	30,000	July 13, 1892	210,000
August 2, 1882	30,000	August 18, 1894	95,000
July 5, 1884	30,000	June 3, 1896	95,000
August 5, 1886	33,750		
August 11, 1888	50,000	Total	738,750

Abstract of contract in force during fiscal year ending June 30, 1898, for quarrying, transporting, and placing stone in north jetty at entrance to Coos Bay, Oregon.

Contractors.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Wakefield & Jacobsen	Oct. 30, 1896	Nov. 7, 1896	Nov. 20, 1896	Dec. 1, 1897

COMMERCIAL STATISTICS.

Coos Bay is in the collection district of southern Oregon. Empire City, on Coos Bay, is the port of entry. The nearest light-house is at Cape Arago, on the south side and west of the entrance.

The following statistics are for the calendar year 1897:

Receipts and shipments.

Articles.	Tons.	Articles.	Tons.
RECEIPTS.		SHIPMENTS—continued.	
Miscellaneous freight	10,072	Chittim bark	24
		Pickets	6
Total	10,072	Apples and potatoes	2,452
		Butter and cheese	351
SHIPMENTS.		Hides and leather	54
		Cattle and hogs	287
Coal	74,549	Fish	1,007
Lumber (14,428,036 feet)	21,642	Woolen goods	23
Laths	459	Miscellaneous	3,244
Fire and match wood	1,199		
Piles, poles, and spars	208	Total	105,607
Ship knees	87		
Cranberries	15		

Arrivals and departures of vessels.

	Steamers.		Sailing vessels.		Total.	
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
Arrived	302	100,856	57	9,087	359	109,943
Cleared	299	60,932	57	10,077	356	71,009
Total	601	161,788	114	19,164	715	180,952

Number of passengers arrived by sea, 1,660; departed by sea, 1,683.

No new lines of transportation were established during the year.

T T 5.

IMPROVEMENT OF HARBOR AT COOS BAY, OREGON (DREDGING).

The status of this proposed improvement has not changed since the last report. (See Annual Report of the Chief of Engineers for 1897, pp. 3387–3388.)

Money statement.

July 1, 1897, balance unexpended	$26,874.92
July 1, 1898, balance unexpended	26,874.92

Appropriations.

Act of—	
August 18, 1894	$13,000
June 3, 1896	14,390
Total	27,390

T T 6.

IMPROVEMENT OF COOS RIVER, OREGON.

The project for improvement (report printed in the Annual Report of the Chief of Engineers for 1895, Part V, pp. 3502–3505) adopted in 1896, provides for removing snags and bowlders and cutting through bars where necessary to secure a channel 50 feet wide from the mouth of the river in Coos Bay to the head of tide on the North and South Forks, or about 5½ miles on the main river and about 8½ miles on each fork, at an estimated cost of $5,000.

The removal of obstructions was actively begun on July 16, 1897, by hired labor, the working party, consisting of 10 men, being equipped with an old snag scow belonging to the Coquille River improvement, rigged with a hoisting engine and various tools and appliances belonging to other appropriations. The steam launch *Butcher Boy* was hired at the rate of $225 per month to move the snag scow from place to place.

A half-tide dike 400 feet long was built on the right side of the channel at Carpenter Shoal in South Fork, to prevent the bank from sliding into the channel, and to contract and aid in deepening the latter. This dike consists of 1,050 tons of rock deposited along a row of 78 piles. It resulted in contracting the channel to its normal width and in securing it out so that the least depth of 3 feet at low tide was obtained where formerly the depth was but 1 foot.

Eleven hundred and fifteen large snags and 575 small snags were removed from the main river and the two forks. These were placed high on the banks and cut up into lengths of 10 to 12 feet.

Eight hundred and sixty-two bowlders were removed from five shoals in the two forks. A number of old piles belonging to an abandoned log boom in the North Fork which completely inclosed about one-fourth of a mile of the channel were also removed.

Operations were suspended on November 5, 1897, at which time the 50-foot channel required by the project had been obtained. The channel has a least depth, at low tide, varying from 2 to 3 feet throughout the 22½ miles covered by the project.

While the work done during the past fiscal year has not been the means of materially increasing the commerce of the stream, it has made it possible to handle the commerce more expeditiously and with less difficulty than before.

Prior to July, 1897, nothing had ever been done toward improving the stream, and its channel was found to be so thickly studded with snags that it was not possible to remove all of them with the funds available. Only the most troublesome obstructions were removed. It is estimated that the smaller obstructions which were left in the stream can be removed for $3,000 in addition to the present available funds, and that $1,500 annually will be sufficient to maintain the desired channel.

Money statement.

July 1, 1897, balance unexpended	$4,870.00
June 30, 1898, amount expended during fiscal year	3,734.74
July 1, 1898, balance unexpended	1,135.26

Appropriation.

Act of June 3, 1896	$5,000

COMMERCIAL STATISTICS.

The traffic on Coos River during the calendar year ending December 31, 1897, was handled by steamer *Coos River*, of 8.30 tons capacity; *Butcher Boy*, of 2.50 tons capacity; *Milton*, of 11.94 tons capacity, and the *Alert*, of 40 tons capacity.

The freight carried was as follows:

Articles.	Tons.	Articles.	Tons.
DOWN.		DOWN—continued.	
Butter and cheese	78	Milk	1,109
Potatoes	1,600	Logs	10,200
Beef, etc	160	Miscellaneous freight	180
Hay	500		
Fruit	900	UP.	
Hides	12		
Hogs	28	General merchandise, loggers' supplies, tools, implements, etc	1,200
Honey	2		
Vegetables	80		
Salmon	485	Total	16,534

Passengers carried on the river by the boats, about 5,000.

T T 7.

IMPROVEMENT OF UMPQUA RIVER, OREGON.

The original project for improvement, adopted in 1871, consequent to report of December 12, 1870 (printed in the Annual Report of the Chief of Engineers for 1871, p. 909), but abandoned consequent to reports printed in the Annual Report of the Chief of Engineers for 1872, pages 986 and 988–989, provided for blasting and removing obstructing rocks in the 70 or 80 miles of the stream between Scottsburg and Rose-

burg, to aid light-draft steamboats to navigate that portion of the river, at an estimated cost of $22,500.

In 1885 the Secretary of War authorized the expenditure of the then unexpended balance of the appropriation of $22,500 of March 3, 1871, in removing some reefs near and below Scottsburg, so as to secure a channel 3 feet deep and 50 feet wide at low water (reports printed in the Annual Reports of the Chief of Engineers for 1880, Part III, pp. 2333–2336, and for 1886, Part III, p. 2006).

In 1890 the project was extended, consequent to reports dated January 31, 1887, and December 22, 1888 (printed in the Annual Reports of the Chief of Engineers for 1887, pp. 2499–2501, for 1889, pp. 2527–2528, and for 1890, pp. 3005–3009), to provide for removing ledges and bowlders at and below Scottsburg, so as to obtain a channel 4 feet deep and 50 feet wide at low water in the 26 miles from Scottsburg to the mouth of the river in the Pacific Ocean. The revised estimate of 1894 (Annual Report of the Chief of Engineers for 1894, Part IV, pp. 2570–2571) placed the additional amount required to complete the project at $6,000, making the total cost $39,500, including all previous appropriations.

The operations up to June 30, 1897, resulted in the removal of many of the principal natural obstructions above Scottsburg, under the original project, in considerably improving the conditions from Scottsburg to the sea under the project for a channel 3 feet deep and 50 feet wide at low water, and in beginning the work of securing a channel 4 feet deep and 50 feet wide at low water from Scottsburg to the sea under the present project.

A contract for blasting and removing stone from the sandstone ledges below Scottsburg was entered into with Normile & Fastabend, of Astoria, Oreg., on May 1, 1897. The contractors began work on the ledges on July 22, 1897, and completed the work, as far as the available funds would permit, on October 20, 1897. The plant used by the contractors consisted of a steam derrick scow and two drill floats. All drilling and loading of holes was done by hand from the floats, and the charges were fired by electricity from the shore. The crew usually consisted of 10 laborers, 1 diver, and 1 foreman.

Throughout the time that the work was in progress the river was at a low stage, and at times of low tide much of the blasted rock was handled by the laborers in the water. At times of high tide this work was done by the diver. The range of tide was usually about 4 feet. The rock was hoisted upon the derrick scow—large pieces with rock hooks and small pieces in a wire basket—and each load was measured by water displacement. The scow was then hauled well to the side of the channel by means of lines running to the shore, and the stone was thrown off. The average amount of stone removed per day was about 9 cubic yards. The total amount of stone blasted and removed by the contractors was 633.68 cubic yards, for which they were paid $8 per cubic yard.

Although the sum available for prosecuting the work did not permit of obtaining the low-water depth of 4 feet at all points, it is believed that the channel as improved meets the present requirements of the one small steamer of about 20 inches draft, which makes daily trips between Scottsburg and the mouth of the river.

Money statement.

July 1, 1897, balance unexpended	$5,970.02
June 30, 1898, amount expended during fiscal year	5,689.91
July 1, 1898, balance unexpended	280.11

Appropriations.

Act of—	
March 3, 1871	$22,500
August 11, 1888	2,000
September 19, 1890	9,000
June 3, 1896	6,000
Total	39,500

Abstract of contract in force during fiscal year ending June 30, 1898, for excavating rock in Umpqua River, Oregon.

Contractors.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Normile & Fastabend	May 1, 1897	May 20, 1897	July 1, 1897	Nov. 1, 1897

COMMERCIAL STATISTICS.

Umpqua River is in the collection district of Southern Oregon. Empire City, on Coos Bay, is the nearest port of entry. The nearest light-house is one-half mile south of the entrance to the river.

The following statistics for the year ending December 31, 1897, have been furnished by Mr. O. B. Hinsdale, of the Gardiner Mill Company and Umpqua River Steam Navigation Company:

UMPQUA RIVER TRAFFIC.

Steamer *Eva*, stern-wheel, about 20 inches draft, made daily trips between Gardiner and Scottsburg, 17½ miles, carrying 1,500 tons of freight and 2,050 passengers.

Smith River empties into Umpqua River from the north about 2 miles above Gardiner. Steamer *Juno*, propeller, 22.28 tons, made triweekly trips between Gardiner and Sulphur Springs, on Smith River, about 15 miles above its mouth, carrying 500 tons of freight and 950 passengers.

COASTWISE TRAFFIC.

The number of coastwise vessels arriving and clearing at Umpqua River during the year was 80. Of these 45 were steamers and 35 sailing vessels.

Receipts and shipments.

Articles.	Received.	Shipped.
	Tons.	*Tons.*
General merchandise	1,500	.....
Agricultural implements	10	.....
Lumber	.....	17,000
Laths	.....	900
Grain	.....	600
Cattle	.....	350
Butter, fruit, furs, etc	.....	60
Total	1,510	18,910

Estimated value of imports	$142,500
Estimated value of exports	150,500

T T 8.

IMPROVEMENT OF MOUTH OF SIUSLAW RIVER, OREGON.

The project for improvement approved by the Secretary of War on August 4, 1891 (report printed in the Annual Report of the Chief of Engineers for 1891, Part V, pp. 3175–3182), provides for obtaining and maintaining a depth of 8 feet at low tide on the bar at the entrance to Siuslaw River by constructing a north jetty 4,500 feet long, and a south jetty 3,200 feet long, located as shown on the charts opposite page 3174 and page 3178 of the Annual Report of the Chief of Engineers for 1891, at an estimated cost of $700,000.

The project provides that the north jetty shall be constructed before the south jetty.

NORTH JETTY.

Up to February, 1897, the receiving wharf, a railway trestle 3,029 feet long, running from the receiving wharf to the root of the jetty, and 483 feet of the jetty itself, had been constructed.

A contract was entered into on February 3, 1897, with Wakefield & Jacobsen, of Portland, Oreg., which provided that the contractors should furnish all the labor and materials necessary to extend the jetty as far as practicable with the available funds, by repairing and extending the tramway, by laying a brush-mattress foundation for the enrockment of the jetty where it was necessary to found the latter on deep sand, and by dumping thereon the enrockment. It also provided that the Government plant used on the work in past years should be turned over to the contractors for use in carrying on the work under their contract, for which use they were to pay the sum of $200 per month.

The contractors began operations in May, 1897, and between then and December 21, 1897, when operations were suspended, furnished, in place, the following-named quantities of materials, at the prices stated in the abstract of their proposal printed in the Annual Report of the Chief of Engineers for 1897, page 3392:

Piles	linear feet..	7,578
Lumber	feet B. M..	35,743
Drift bolts	pounds..	1,850
Brush mattress	cubic yards..	1,887⅘
Stone	tons..	42,427½

Under this contract the tramway and jetty were repaired, and also extended 428 feet, giving the jetty proper a total length of 911 feet. The jetty is up to high-tide level throughout that distance.

The north jetty has reached a point where all future extension may be expected to have a more or less beneficial influence on the river entrance. In its present state it is probable that it will at least prevent the channel from shifting as far to the north as formerly. It is when the channel is in this northern position that the worst conditions prevail. The river entrance channel is now some distance south of the jetty, with a sand spit, bare at low tide and nearly parallel to the jetty, which protects it at present from the scouring action of the current. The channel is nearly straight, has a mean low-tide depth of 7½ feet, equivalent to 14 feet at mean high tide, and the latter affords a safe entrance for the vessels engaged in the lumber trade of the Pacific Coast.

Money statement.

July 1, 1897, balance unexpended	$26,672.63
June 30, 1898, amount expended during fiscal year	24,576.93
July 1, 1898, balance unexpended	2,095.70
July 1, 1898, outstanding liabilities	60.00
July 1, 1898, balance available	2,035.70
Amount (estimated) required for completion of existing project	578,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	100,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
September 19, 1890	$50,000
July 13, 1892	20,000
August 18, 1894	25,000
June 3, 1896	27,000
Total	122,000

Abstract of contract in force during fiscal year ending June 30, 1898, for extending north jetty at mouth of Siuslaw River, Oregon.

Contractors.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Wakefield & Jacobsen	Feb. 3, 1897	Feb. 27, 1897	May 1, 1897	Dec. 31, 1897

COMMERCIAL STATISTICS.

The Siuslaw River is in the collection district of Yaquina, on Yaquina Bay. The nearest light-house is at Heceta Head, 8¼ miles north of the river entrance.

The following statement of traffic for the year ending December 31, 1897, has been compiled from the monthly reports of Mr. Morton L. Tower, of Florence, Oreg.

Receipts and shipments.

Articles.	Tons.	Articles.	Tons.
RECEIPTS.		SHIPMENTS.	
Flour and feed	65	Salmon	746
General merchandise	986	Lumber (328,000 feet B. M.)	292
		General produce	132
Total	1,051	Total	1,170

Arrivals and departures of vessels.

Coasting vessels.	Number.	Aggregate tonnage.
Arrivals	39	1,608
Departures	39	1,452
Total	78	3,060

Classification of vessels: Steamers, 56; tugs, 16; sail vessels, 6. Number of passengers arrived by sea, 124; departed by sea, 159.

T T 9.

IMPROVEMENT OF ALSEA RIVER, OREGON.

The project for improvement (report of survey printed in the Annual Report of the Chief of Engineers for 1895, Part V, pp. 3505–3509) adopted in 1896, provided for removing isolated rocks, and snags, stumps, etc., in the 31 miles of river from the upper forks down to the head of tide, so as to provide a less dangerous means for transporting the products of the Upper Alsea Valley during the higher stages of the stream. The products are brought down in roughly constructed push boats, costing from $16 to $20 each, which are abandoned at the end of the trip. The estimated cost of the improvement was placed at $3,000.

Under a contract with Charles P. Church, of Portland, Oreg., dated February 10, 1897, the isolated rocks and snags, logs, stumps, etc., which formerly obstructed navigation at high stages in the 31 miles covered by the project were removed, and the trees and brush on several islands were cut to the ground and burned to prevent them from collecting drift. The contractor began work on June 25, 1897, and completed it in September, 1897.

Money statement.

July 1, 1897, balance unexpended	$2,970.81
June 30, 1898, amount expended during fiscal year	1,920.19
July 1, 1898, balance unexpended	1,050.62

Appropriation.

Act of June 3, 1896	$3,000

Abstract of contract in force during fiscal year ending June 30, 1898, for removing obstructions in Alsea River, Oregon.

Contractor.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Charles P. Church	Feb. 10, 1897	Feb. 26, 1897	(a)	Oct. 15, 1897

a The contract provided that work should be begun by the contractor as early in 1897 as the condition of the river would permit.

It has been impracticable to obtain commercial statistics for this stream.

T T 10.

IMPROVEMENT OF YAQUINA BAY, OREGON.

Prior to improvement the depth over the bar at the entrance to the bay varied from 7 to 8 feet at low tide, and there were three shifting channels which constantly changed, not only in position, but also in depth. The mean rise of tide was about 7 feet.

The original project of 1880* and the modified projects and revised estimates of cost of 1882,† 1888,‡ 1890,§ and 1892‖ provided for constructing two high-tide rubblestone jetties, the south jetty to be 3,748 feet long and the north jetty 2,300 feet long, to permanently close up the south channel and deflect the flow of the waters so as to scour out and maintain the middle channel with the least depth of 17 feet at high tide, at an estimated cost of $755,000. The jetties provided for by the foregoing projects were practically complete at the close of the fiscal year ending June 30, 1896, and through their agency the south channel had been permanently closed up and the depth of 15 feet at mean lower low water obtained in the middle channel.

The sundry civil act of March 2, 1895, provided—

That the President of the United States is hereby authorized to appoint a board, to consist of three officers of the Engineer Corps, who shall make an examination of the bar of the Yaquina Bay, in Oregon, with a view to a project for deeper water, and shall report the result of such investigation, with estimate of cost, to the next regular session of Congress.

The report of the board of officers, dated October 11, 1895 (printed in the Annual Report of the Chief of Engineers for 1896, Part V, pages 3284–3309), was in effect that if any further permanent deepening of the bar could be made it would be only by extending the north jetty 2,100 feet and the south jetty 2,000 feet, the new portions of the jetties to be parallel and 1,000 feet apart, and to be built of heavy riprap brought up to the level of high tide. The board in its report also submitted that, in the event that such further extension of the jetties was made, the south jetty should have on the channel side groins of riprap every 300 feet, to prevent it from being undermined; that a spur 800 feet long should be built from the channel side of the present south jetty, for the purpose of obtaining a greater depth of water over the inner bar, that had formed in recent years; and that all projecting rocks in the path of vessels should be blasted out to the general level of the rock bottom. The cost of this additional work was estimated by the board at $1,025,800, making the estimated total cost, including previous appropriations, $1,710,800.

The river and harbor act of June 3, 1896, appropriated $25,000 for the work, and also provided—

That contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the project as recommended by the Board of Officers of the Engineer Corps October eleventh, eighteen hundred and ninety-five, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one million dollars, exclusive of amount herein and heretofore appropriated.

Under date of February 15, 1898, the Secretary of War authorized that a continuing contract be made for prosecuting the work outlined in the report of the board of engineer officers dated October 11, 1895, and in accordance with the act of Congress of June 3, 1896. The specifications for the proposed contract were forwarded on March 12, 1898, and were approved by the Secretary of War May 9, 1898.

As there is a possibility that further extension of the south jetty may not be necessary, the specifications of the contract which it is proposed to enter into require that the north jetty shall be extended first.

No work was done on the jetties during the past fiscal year beyond that incident to watching them and the plant and other property used in former years in constructing them.

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* Annual Report, Chief of Engineers, 1881, Part III, p. 2589.
† *Ibid.*, 1882, Part III, p. 2679.
‡ *Ibid.*, 1889, Part IV, p. 2517.
§ *Ibid.*, 1890, p. 2967.
‖ *Ibid.*, 1893, Part IV, p. 3351.

According to reports made by masters of steamers, the depth of water on the bar at low tide during the past year has ranged from 14 to 16 feet.

Money statement.

July 1, 1897, balance unexpended	$25,041.04
June 30, 1898, amount expended during fiscal year	2,420.32
July 1, 1898, balance unexpended	22,620.72
July 1, 1898, outstanding liabilities	85.33
July 1, 1898, balance available	22,535.39
Amount (estimated) required for completion of existing project	1,000,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	400,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—		Act of—	
June 14, 1880	$40,000	September 19, 1890	$165,000
March 3, 1881	10,000	July 13, 1892	85,000
August 2, 1882	60,000	August 18, 1894	50,000
July 5, 1884	50,000	June 3, 1896	25,000
August 5, 1886	75,000		
August 11, 1888	150,000	Total	710,000

COMMERCIAL STATISTICS.

Yaquina Bay is in the collection district of Yaquina. Yaquina City is the port of entry. The nearest light-house is at Yaquina Head, 4½ miles north of the entrance.

The following statistics are for the calendar year 1897:

Receipts and shipments.

Articles.	Tons.	Articles.	Tons.
RECEIPTS.		SHIPMENTS.	
General merchandise	1,513	Potatoes	75
Salmon cases	48	Bark	27
Salmon barrels	1	Bran	331
Sugar	166	Car wheels	39
Salt	62	Wood and lumber	62
Tin and lead	10	Salmon	81
Malt	84	Stave bolts	944
Lumber	150	Feed	251
Iron	20	Oats	1,148
Railroad materials	20	Miscellaneous freight	1,432
Chittim bark	4	Stone	4,870
Hay	27	Flour	3,684
Barley	10	Wheat	155
Total	2,115	Total	13,269

Passengers arrived by sea	426
Passengers departed by sea	410

Arrivals and departures.

Steam vessels.	Tonnage.	Draft.	Arrivals.	Departures.
Truckee	295.84	.....	7	7
Tillamook	208.57	.....	1	1
President	.....	.....	4	4
Robarts (tug)	24.15	6.5	25	25
Tonquin (tug)	18.61	.....	8	7
Homer	381.04	17	.....	1
Chilkat	106.45	.....	3	3
Protection	.....	.....	1	.....
South Coast	209.35	.....	1	1
Noyo	229.84	.....	3	3
W. H. Harrison	52.86	.....	4	4
Bismark	144.40	.....	1	1
Farallon	565.55	18.5	19	19
Columbine	212.07	.....	1	1
Resolute (tug)	44.99	.....	.....	1
Scotia	132.73	.....	4	5
Total	.....	.....	82	83

T T II.

IMPROVEMENT OF NESTUGGA RIVER, OREGON.

The river and harbor act of June 3, 1896, provided $6,000 to remove a rocky reef on the south side of the entrance to Nestugga Bay about 100 feet long, from 24 to 30 feet wide, and rising to about the level of extreme low tide, which interfered with navigation (report printed in the Annual Report of the Chief of Engineers for 1895, Part V, pp. 3509–3510).

The work of removing the reef under a contract with Normile & Fastabend, of Astoria, Oreg., dated May 1, 1897, at the rate of $3.75 per cubic yard, was begun late in May, 1897, and was completed in October, 1897, 1,388 cubic yards of stone having been blasted from the reef, giving the depth of 9 feet at low tide over it.

Money statement.

July 1, 1897, balance unexpended	$5,917.22
June 30, 1898, amount expended during fiscal year	5,385.10
July 1, 1898, balance unexpended	532.12

Appropriation.

Act of June 3, 1896	$6,000

Abstract of contract in force during fiscal year ending June 30, 1898, for removing a rocky reef to the depth of 9 feet below low water in the throat of the entrance to Nestugga Bay, Oregon.

Contractors.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
Normile & Fastabend	May 1, 1897	May 20, 1897	June 1, 1897	Dec. 1, 1897

It has not been practicable to obtain commercial statistics for this locality.

T T 12.

IMPROVEMENT OF TILLAMOOK BAY AND BAR, OREGON.

The project for improvement and the work accomplished up to the end of the last fiscal year are shown in detail in the Annual Report of the Chief of Engineers for 1897, Part IV (pp. 3397–3404).

A chart of Tillamook Bay, showing the four channels in the bay and the several streams which empty into the bay from the southeast, appears between pages 3248 and 3249 of the Annual Report of the Chief of Engineers for 1896.

On account of the limited sum available the expenditures during the fiscal year ending June 30, 1898, were confined to payment for services of a watchman and to removing an occasional troublesome snag in Hoquarten Slough.

Money statement.

July 1, 1897, balance unexpended	$1,478.14
June 30, 1898, amount expended during fiscal year	548.06
July 1, 1898, balance unexpended	930.08
Amount (estimated) required for completion of existing project	52,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	52,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
August 11, 1888	$5,200
September 19, 1890	500
July 13, 1892	15,000
August 18, 1894	16,000
June 3, 1896	17,000
Total	53,700

COMMERCIAL STATISTICS.

Tillamook Bay is in the collection district of Oregon. Astoria, near the mouth of the Columbia River, is the nearest port of entry.

Nearest light-house is at Cape Meares, about 4 miles south of the entrance.

The following statistics for the calendar year ending December 31, 1897, were furnished by Mr. F. R. Madison, inspector of customs at Bay City, Oreg.:

The number of vessels arriving at and clearing from Tillamook Bay during the year was 141, of which 100 were steamers and 41 were schooners.

Receipts and shipments.

Articles.	Receipts.	Articles.	Shipments.
	Tons.		*Tons.*
General merchandise	3,400	Lumber (15,000,000 feet)	22,500
Machinery and implements	50	Canned salmon (in cases)	875
Flour and feed	500	Salted salmon (in barrels)	30
Cannery supplies	50	Butter and cheese	2,000
Total	4,000	Total	25,405

Passengers arrived by sea during the year	400
Passengers departed by sea during the year	500

Coastwise bay and river traffic.—Steam schooner *W. H. Harrison*, draft 7 feet, tonnage 75, made irregular trips between Astoria, Oreg., and Tillamook City, Oreg. Steam schooner *Miami*, of Tillamook City, draft 5 feet, tonnage 42, plied between ports whenever traffic was offered it. Steam schooner *R. P. Elmore*, tonnage 62, made regular trips between Astoria and Tillamook City every eight days. Steam launch *Louisa*, tonnage 8, and gasoline launch *Irene*, tonnage 3, plied between the different points on the bay, doing a general freight and passenger business.

T T 13.

IMPROVEMENT OF UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON.

[This work was in the charge of Capt. Harry Taylor, Corps of Engineers, until November 30, 1897.]

The above is the official designation of the 125 miles of the Columbia River from Celilo, Oreg., up to the mouth of Snake River, and the 150 miles of the latter stream from its mouth up to Asotin, Wash., about 7 miles above Lewiston, Idaho. Both streams in these 275 miles were originally so obstructed by rocky bars, rapids, and narrow and crooked channels that light-draft steamboat navigation was difficult and hazardous. The principal obstructions originally existing are shown in the Annual Reports of the Chief of Engineers for 1875 (Part II, p. 772–787) and for 1877 (Part II, pp. 1036–1041).

A full and continuous survey from Celilo to Asotin has never been made.

The first appropriation for improving Upper Columbia River was made by the act of Congress of June 10, 1872, and the improvement of Snake River was added by the act of Congress of August 14, 1876.

The improvement has been conducted with the view of obtaining a low-water channel depth of about 5 feet in the Upper Columbia and about 4 feet in the Snake by blasting out the worst obstructions and by constructing deflecting dikes to concentrate and deepen the water at Log Cabin Rapids and Wild Goose Island Rapids, both in Snake River 38 and 73 miles, respectively, below Lewiston. The work of improvement has since 1882 been confined to that portion of Snake River from Riparia up to Asotin, the importance of that portion of Snake River for purposes of navigation having increased each year, while the streams from Riparia down to Celilo have been abandoned by steamers since the construction of railroads in the vicinity.

During the past year operations were confined to extending a loose stone dike from the lower end of Goose Island toward the upper end of a small island about 1,100 feet below Goose Island, so as to force the water formerly passing between the islands to pass over adjacent rapids, thereby increasing the depth over the latter.

The dike was constructed for the distance of 666 feet. Its base has an average width of 12 feet, its crest a width of about 2 feet, and it rises slightly above low water. The rock used was quarried about 2 miles above the dike. The Oregon Railroad and Navigation Company's steamer *Spokane* was employed to convey the rock from the quarry to the dike. The steamer arrived at the scene of operations on September 5 and was kept in commission until September 22. The steamer delivered 14 loads of rock, carrying it on the deck, or about 1,750 tons. The steamer also devoted two days to scraping several of the more troublesome bars in the vicinity of the dike with a large rake, made by bolting heavy pieces of iron together, weighing 3,000 pounds. The effect of the

dike has been to raise the water 6 inches along the channel side, and the scraping caused a scour of at least 6 inches at the rapids, thus increasing the depth of water at Lower Goose Island Rapid about 1 foot.

Prior to beginning work on the dike the river steamers in ascending the river at this point were compelled to use a line; the dike, even in its incomplete state, has effected improvement to the extent that steamers now experience no difficulty in ascending the rapids.

Money statement.

July 1, 1897, balance unexpended	$2,768.05
December 30, 1897, reimbursement for property transferred *	414.00
	3,182.05
June 30, 1898, amount expended during fiscal year	2,461.38
July 1, 1898, balance unexpended	720.67
Amount (estimated) required for completion of existing project	Indefinite.
Amount that can be profitably expended in fiscal year ending June 30, 1900	20,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Upper Columbia River, act of—		
June 10, 1872	$50,000	
June 23, 1874	20,000	
March 3, 1875	35,000	
Total		$105,000
Upper Columbia and Snake rivers, act of—		
August 14, 1876	15,000	
June 18, 1878	20,000	
March 3, 1879	20,000	
June 14, 1880	15,000	
March 3, 1881	15,000	
August 2, 1882	6,000	
July 5, 1884	20,000	
August 5, 1886	10,000	
August 11, 1888	10,000	
September 19, 1890	20,000	
July 13, 1892	15,000	
August 18, 1894	5,000	
June 3, 1896	5,000	
Total		176,000
December 30, 1897, reimbursement for property *		414
Aggregate		281,414

COMMERCIAL STATISTICS.

Two stern-wheel steamboats, the *Lewiston*, tonnage 539.92, and the *Almota*, tonnage 502.35, draft of water fully laden 4 feet 6 inches, light 1 foot 9 inches, owned by the Oregon Railroad and Navigation Company, make daily trips, excepting Saturday, between Lewiston and Riparia, 77 miles, carrying freight and passengers.

This company is now building another steamboat to ply between those points.

* Transfer of property authorized by Chief of Engineers, United States Army, November 17, 1897.

It has been impracticable to obtain a statement of the commerce handled on the stream during the past year, but it is known that a great deal of wheat was, as in former years, carried by the steamboats from various points between Lewiston and Riparia to the latter point for shipment by rail to Portland, from which latter point it is exported to Europe.

T T 14.

IMPROVEMENT OF COLUMBIA RIVER AT THREE-MILE RAPIDS, AND THE CONSTRUCTION AND EQUIPMENT OF A BOAT RAILWAY FROM THE FOOT OF THE DALLES RAPIDS TO THE HEAD OF CELILO FALLS.

The project adopted in 1894 (act of Congress of August 17, 1894), consequent to report of Board of Engineers (printed in the Annual Report of the Chief of Engineers for 1894, Part IV, pp. 2664–2680), provides for the construction and equipment of a boat railway on the Oregon shore of the Columbia River from the foot of The Dalles Rapids to the head of Celilo Falls, and for the improvement of Three-mile Rapids below the lower terminus of the proposed boat railway, at an estimated cost of $2,264,467.

The obstructions which render navigation impossible in the 12 miles of the Columbia from Three-mile Rapids up to Celilo Falls, and the plan for passing boats around them by means of a boat railway about 9 miles in length, are described in the Annual Report of the Chief of Engineers for 1894 (Part IV, pp. 2664–2680).

The line of the proposed boat railway is shown on the map opposite page 3590 of the Annual Report of the Chief of Engineers for 1895, Part V.

The navigable capacity of the Columbia, and the scope and character of the country which would be benefited by an improvement that would enable boats to pass the obstructions between Three-mile Rapids and Celilo Falls, are described in the Annual Reports of the Chief of Engineers for 1885 (Part III, p. 2426), for 1886 (Part III, p. 1942), and for 1894 (Part IV, p. 2664).

The work so far done under the project has been confined to making a survey of the line of the proposed boat railway, in preparing plans for it and its appurtenances, and in acquiring title to the necessary land. For the right of way, and for terminal and other facilities of the boat railway, an area of 297.08 acres is required, and an additional area of 26.75 acres is required to provide for changes in the track of the Oregon Railroad and Navigation Company necessary to accommodate the line of the boat railway, or a total of 323.83 acres.

Up to June 30, 1898, title to, or right of way over, 188.09 acres of land had been acquired by the United States, as follows:

Acres.	Acquired from—	How acquired.
5.19	United States	Withdrawn from sale by President's order of Jan. 31, 1893.
67.58	State of Oregon	By purchase.
1.90	J. C. Willmon	Do.
84.29	The Dalles Packing Co	By condemnation proceedings.
.16	James Wesley	By purchase.
13.10	Wm. Michell (two-thirds)	By condemnation proceedings.
	Leopold F. Schmidt (one-third).	By purchase.
16.06	Oregon Railroad and Navigation Co.	By purchase. The company expended $1,030.06 for land upon which to move its track to accommodate line of boat railway, and was reimbursed by United States by authority of Secretary of War.

On June 30, 1898, 135.74 acres of land remain to be acquired by the United States. The names of the owners of this land, and the status of proceedings, etc., as of that date, to acquire title to it are as follows:

Acres.	Owned by—	Remarks.
17	I. H. Taffe	Amount awarded owner in first trial for condemnation of right of way, $14,200; second trial, $17,500. United States filed application for retrial, whereupon owner agreed to abide by the decision of the United States judge who had tried the cases. It is understood that the latter recently decided that the owner is entitled to $1,000.
94.30	Seufert Bros. Co	Amount awarded owners in first trial for condemnation of right of way, $25,067.50; second trial, $35,000; third trial, recently concluded, $9,000.
24.44	Oregon Railroad and Navigation Co.	Right of way is to be acquired in connection with negotiations for surrender of such portions of the company's right of way, etc., as are needed for the boat railway.

On March 24, 1898, the Oregon Railroad and Navigation Company, through its president, inquired whether the United States was ready to enter into negotiations providing for the surrender by the company of its right of way at such points as were necessary to accommodate the boat railway. On April 13, 1898, the Chief of Engineers authorized that such negotiations be entered into, any arrangement to be subject to the approval of the Secretary of War. A preliminary proposition was made the company on April 23, 1898, but no reply has been received.

On December 8, 1894, all Government lands on the south side and within 6 miles of the Columbia River, between The Dalles and Celilo, Oreg., were temporarily withdrawn from disposition by the Department of the Interior until it could be determined what particular tracts should be permanently reserved for the boat railway. It having since been determined that but 5.10 acres was all of the Government land that would be required for that purpose, that area was permanently withdrawn from sale by the President's order of January 31, 1898, and the order of the Interior Department of December 8, 1894, so far as the remainder of the land was concerned, was vacated on March 15, 1898.

Money statement.

July 1, 1897, balance unexpended	$238,817.60
June 30, 1898, amount expended during fiscal year	4,416.22
July 1, 1898, balance unexpended	234,401.38
July 1, 1898, outstanding liabilities	19.95
July 1, 1898, balance available	234,381.43
Amount (estimated) required for completion of existing project	*2,014,467.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
August 18, 1894	$100,000
June 3, 1896	150,000
Total	250,000

* Erroneously given as $2,114,467.00 in last Annual Report.

T T 15.

CONSTRUCTION OF CANAL AT THE CASCADES, COLUMBIA RIVER, OREGON.

The project for the construction of a canal and locks to pass steamers around the Cascades of the Columbia River, about 150 miles above the mouth of the latter, in the Pacific Ocean, and the progress of the work of constructing the canal and locks up to the close of the last fiscal year, are stated in detail in the Annual Report of the Chief of Engineers for 1897 (Part IV, pp. 3416–3419).

The operations during the fiscal year ending June 30, 1898, were as given below, and were in accordance with and incident to the modified plans and estimate of cost for completing the canal and locks recommended in the report of the Board of Engineer Officers dated October 18, 1894. (Report and estimate of cost printed in the Annual Report of the Chief of Engineers for 1895, Part V, pp. 3571–3582.)

The operations during the past year were conducted by hired labor and with plant purchased and used on the work in former years.

Three thousand two hundred and sixty-seven cubic yards of earth were added to the embankment separating the Columbia River from the canal (shown on chart opposite p. 2246 of the Annual Report of the Chief of Engineers for 1884, Part III), pursuant to raising the embankment where necessary to make it conform to the flood height of 1894.

Nine thousand eight hundred and sixty-nine cubic yards of stone, varying from small spalls to bowlders containing about 1 cubic yard, were used as rock filling in revetting the Columbia River or north slope of the embankment separating the river from the canal.

This stone filling was closely placed, its slope and thickness varying with the velocity of the current to which it is exposed. Although the work of revetting the north slope of this embankment is not complete, the slope is now considered to be safe from damage from a flood equal in height to the one of 1894.

In the last Annual Report (p. 3419) it was stated that, in obtaining stone for revetting the north slope of the embankment separating the river from the canal, such stone as would be useful in completing the walls between the upper lock gate and upper guard gate masonry was laid aside, with the view of using it for that purpose as soon as additional funds become available. This practice was continued during the past year, 10,760 cubic feet of such stone being quarried and laid aside. There is now on hand enough of this class of stone to complete the north wall of the upper lock, and also some of the larger stones (the most difficult to obtain) for the south wall.

One hundred and fifty-four square yards of stone quarried, too small to be used in completing the walls between the upper-lock gates and upper guard-gate masonry, were also laid aside, to be used as facing for the riprap yet to be placed on the slopes north and south of the canal.

The work next in importance was that of placing additional pumping machinery in the power pit. This work included that of placing another 12-inch centrifugal pump and connections, grouting up I-beam supports and journal boxes in concrete, drilling a hole for a 12-inch suction pipe from the power pit to the main culvert, and placing the suction pipe and sleeve. The pumping machinery now consists of two brass 12-inch centrifugal pumps connected by belts to a horizontal countershaft, which is driven by the vertical shaft of a turbine by means of bevel gears. The turbine is of the combined "inward and downward flow" type. The wheel is 27 inches in diameter, and is set in a wrought-iron case resting on and bolted to a 39-inch gate valve,

the lower flange of which is bolted to a cast-iron floor plate anchored and grouted to the concrete floor. The turbine is expected to develop from 40 to 80 horsepower, according to the stage of the water. The culvert conveying the water to the turbine enters the power pit at the side of the wall 7 feet above the floor, a short iron tube connecting the end of the culvert to the turbine casing. The suction passage leading from the lock chamber is rectangular in section, 24 by 24 inches, and passes horizontally under the power pit, and then rises vertically to the floor of the pit. The upper end of this passage is covered with a cast-iron plate grouted and bolted to the floor. In this plate are two pipes 12 inches in diameter, screwed on the underside of the plate and reaching about 12 inches below the canal floor. On the upper side of the plate are bolted two check valves, each connected with a gate valve and suction pipe to its respective pump. The discharge pipes of the pumps lead to two gate valves bolted to the same floor plate which carries the turbine discharge-gate valve. The belt pulleys on the countershaft are provided with friction clutches; hence the two pumps are entirely independent of each other. The second pump, placed in position during the past fiscal year, in addition to drawing from the main suction chamber, was arranged to pump out the south culvert for the purpose of removing the valve or other necessary work in the culvert, a hole for the suction pipe being cut through the 5 feet of concrete masonry which intervened between the power pit and the culvert. In this hole a cast-iron sleeve was built and the suction pipe was passed through it to the bottom of the culvert. When not in use in pumping out the culvert the suction pipe is withdrawn and a blind flange is bolted over the top of the sleeve casting. The pumps are primed and the leakage into the pit dealt with by carrying a 3-inch pipe down into the pit from the high-pressure water supply, and suitably connecting up with jet pumps, the discharge being carried into the turbine discharge culvert through the floor plate.

Money statement.

July 1, 1897, balance unexpended	$203,845.29
June 30, 1898, amount expended during fiscal year	183,138.86
July 1, 1898, balance unexpended	20,706.43
July 1, 1898, outstanding liabilities	576.80
July 1, 1898, balance available	20,129.63
Amount (estimated) required for completion of existing project	334,260.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	334,260.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—		Act of—	
August 14, 1876	$90,000	August 11, 1888	$300,000
June 18, 1878	150,000	September 19, 1890	435,000
March 3, 1879	100,000	July 13, 1892	326,250
June 14, 1880	100,000	March 3, 1893	1,239,653
March 3, 1881	100,000	June 3, 1896	50,000
August 2, 1882	265,000	June 11, 1896	173,597
July 5, 1884	150,000		
August 5, 1886	187,500	Total	3,673,000

For commercial statistics, etc., see Annual Report, "For operating and care of canal and locks at the Cascades of the Columbia River, Oregon."

T T 16.

ıTING AND CARE OF CANAL AND LOCKS AT THE CASCADES OF THE COLUMBIA RIVER, OREGON.

canal and locks around the Cascades of the Columbia River, 150 miles above the mouth of the latter in the Pacific Ocean, and enable steamboats drawing 8 feet of water to run as far up the ı as The Dalles, Oregon, about 210 miles above the mouth, for- opened to navigation on November 5, 1896, were operated con- ısly during the past fiscal year excepting on twenty-four days in 1898, when navigation through them was impossible on account h water.

ar composed largely of broken pieces of bed rock was formed in wer entrance to the canal by the usual summer freshet which ed during the summer of 1897. This bar was dredged during w-water period last winter, 1,845 cubic yards of material being ed from it.

disabled condition of the valve in the main culvert on the south f the lower lock was reported in the Annual Report of the Chief gineers for 1897 (p. 3423). During February and March, 1898, alve was removed for repairs. This was accomplished by bulk- ıg all the openings to the main culvert on the south side of the lock, and then pumping out the culvert with a 12-inch pump. isabled valve was found to be broken almost completely in two, ally. The new valve, which it is proposed to have made during esent summer, together with its fittings, will weigh between 12 3 tons, and until it is made and placed in position the lower lock ə operated with the north valve only.

Money statement.

1897, balance unexpended	$415.28
21, 1897, allotment	4,000.00
r 30, 1897, allotment	1,500.00
	5,915.28
), 1898, amount expended during fiscal year	4,533.79
1898, balance unexpended	1,381.49
1898, outstanding liabilities	190.85
1898, balance available	1,190.64

Allotments.

ber 4, 1896	$2,500
, 1897	350
21, 1897	4,000
r 30, 1897	1,500
otal	8,350

Detailed statement of expenditures made in operating and caring for canal and locks at Cascades of the Columbia River, Oregon, during the fiscal year ending June 30, 1898, submitted in compliance with the river and harbor act of July 5, 1884.

Date.	Voucher No.	To whom paid.	For what paid.	Amount.
1897.				
July	16	Sundry persons	Personal services	$260.00
August	11	....do	....do	260.00
	92	J. H. Spadone	Hose, etc	17.50
September	11	Sundry persons	Personal services	260.00
October	9	....do	....do	260.00
November	18	....do	....do	312.00
	110	W. C. Noon Bag Co	Duck, etc	13.84
December	12	Sundry persons	Personal services	681.63
	20	Bridal Veil Lumbering Co	Lumber	153.42
	23	Wolff & Zwicker Iron Works	Castings	21.20
	24	Tatum & Bowen	Supplies	43.96
1898.				
January	14	Sundry persons	Personal services	534.83
	19	H. Groth	Firewood	4.00
	30	Oregon Telephone and Telegraph Co.	Telephone service	1.10
February	5	Sundry persons	Personal services	434.08
	33	Corbett, Failing & Robertson	Oilers	1.40
	34	Cleveland Oil and Paint Manufacturing Co	Paint	16.50
	46	The J. K. Gill Co	Record book	.68
March	8	Sundry persons	Personal services	416.50
	32	Goodyear Rubber Co	Divers' mittens	3.00
April	9	Sundry persons	Personal services	484.91
	37	Thos. K. Muir & Co	Asphalt	4.50
	38	The Chas. F. Beebe Co	Oakum	3.00
	39	Oregon Telephone and Telegraph Co.	Telephone service	3.70
	40	J. H. Spadone	Leather lacing	2.15
	54	LeCount Bros	Record book	2.25
May	4	Sundry persons	Personal services	138.00
	13	Wolff & Zwicker Iron Works	Split pulley	27.00
	14	W. P. Fuller & Co	Waste, etc	3.25
June	3	Sundry persons	Personal services	153.00
	11	The J. K. Gill Co	Letter files	1.40
		Total expended		4,533.79

Distribution of expenditures made in operating and caring for canal and locks at Cascade of the Columbia River, Oregon, during the fiscal year ending June 30, 1898.

Date.	Voucher No.	To whom paid.	Office, superintendence, and contingencies.	Labor.	Tools, fuel, oil, etc.	Materials for repairs.
1897.						
July	16	Sundry persons		$260.00		
August	11	....do		260.00		
	92	J. H. Spadone				$17.50
September	11	Sundry persons		260.00		
October	9	....do		260.00		
November	18	....do		312.00		
	110	W. C. Noon Bag Co				13.84
December	12	Sundry persons		681.63		
	20	Bridal Veil Lumbering Co				153.42
	23	Wolff & Zwicker Iron Works				21.20
	24	Tatum & Bowen				43.96
1898.						
January	14	Sundry persons		534.83		
	19	H. Groth			$4.00	
	30	Oregon Telephone and Telegraph Co.	$1.10			
February	5	Sundry persons		434.08		
	33	Corbett, Failing & Robertson			1.40	
	34	Cleveland Oil and Paint Manufacturing Co				16.50
	46	The J. K. Gill Co	.68			
March	8	Sundry persons		416.50		
	32	Goodyear Rubber Co				3.00
April	9	Sundry persons		484.91		
	37	Thos. K. Muir & Co				4.50
	38	The Chas. F. Beebe Co				3.00
	39	Oregon Telephone and Telegraph Co.	3.70			

Distribution of expenditures made in operating and caring for canal and locks at Cascades of the Columbia River, Oregon, during the fiscal year ending June 30, 1898—Continued.

Date.	Voucher No.	To whom paid.	Office superintendence, and contingencies.	Labor.	Tools, fuel, oil, etc.	Materials for repairs.
1898.						
April	40	J. H. Spadone				$2.15
	54	LeCount Bros	$2.25			
May	4	Sundry persons		$138.00		
	13	Wolff & Zwicker Iron Works				27.00
	14	W. P. Fuller & Co			$8.25	
June	3	Sundry persons		153.00		
	11	The J. K. Gill Co	1.40			
		Total	9.13	4,194.95	13.65	316.06

Summary.

Office, superintendence, and contingencies	$9.13
Labor	4,194.95
Tools, fuel, oil, etc	13.65
Materials for repairs	316.06
Total	4,533.79

COMMERCIAL STATISTICS.

Canal at Cascades, Oregon.—Summary of business, etc., during fiscal year ending June 30, 1898.

Month.	Average gauge readings, 12 m.		Number of lockages.	Locks operated.	Number of passages.				
	Upper.	Lower.			Stern-wheel.	Raft.	Propeller.	Barge or sail.	Total.
1897.				*H. M.*					
July	113.5	98.2	68	19 31	68		2		70
August	105.9	86.9	59	15 12	58			1	59
September	101.6	80.3	60	14 26	60	2		1	63
October	98.7	75.9	79	20 5	86	3		1	90
November	100	77.3	76	21 10	90	1			91
December	102.4	81.3	80	22 47	92				92
1898.									
January	100.1	78	52	13 7	52				52
February	102.2	81.2	48	13 8	48				48
March	102.2	81.1	54	20 28	54	2		3	59
April	105.3	85.7	53	18 20	52		1		53
May	123.5	109.3	11	3 35	10		1		11
June	116	101.3	52	16 11	52				52
Total	1,271.4	1,037.5	692	203	722	8	4	6	740
Average	106	86.5	57.7	18	60.2	0.67	0.33	0.5	61.67

Month.	Registered tonnage.	Freight carried.	Passengers.	Vessels delayed.	
		Tons.	*Number.*	*Number*	*H. M.*
1897.					
July	24,723.40	1,074.20	6,583	2	0 47
August	18,160.40	913.20	2,926		
September	18,364.74	2,200.10	2,311	3	8 30
October	25,294.36	4,458.96	2,630		
November	24,934.28	3,269.43	2,269		
December	25,565.54	913.15	2,462		
1898.					
January	16,374.26	1,126.17	1,800		
February	15,150.24	1,005.55	1,528	2	2 41
March	17,044.02	1,363.18	2,380	5	3 32
April	15,480.97	1,252.75	2,178		
May	3,240.07	190.50	596		
June	16,002.94	1,045.49	2,664		
Total	220,335.22	18,812.68	30,327	12	15 30
Average	18,361.27	1,569.39	2,527		

Statement of traffic passing through canal at Cascades, Oregon, during fiscal year ending June 30, 1898.

Month.	Bound up.										Bound down.		
	Hay.	Cattle.	Horses.	Sheep.	Miscellaneous live stock.	Berries and fruit.	Lumber.	Miscellaneous merchandise.	Total cargo.	Passengers.	Wheat.	Flour.	Miscellaneous grain.
1897.	*Tons*	*No.*	*No.*	*No.*	*No.*	*Lbs.*	*Ft. B. M*	*Tons.*	*Tons.*	*No.*	*Lbs.*	*Lbs.*	*Lbs.*
July	.....	2	64	27	.....	.....	43,000	548.50	605.75	2,468	5,020	44,000	.....
August	.....	6	39	.....	.....	.....	20,257	433.43	496.43	1,650	.....	110,000	.....
September	.....	2	66	21	1	.....	34,806	570.02	663.47	1,164	2,147,762	1,000	20,000
October	17.50	130	172	16	15	2,000	77,790	753.04	1,075.37	1,143	5,956,990	.....	2,000
November	6	114	53	.....	.....	.....	45,063	655.32	813.42	900	4,345,050	20,000	.....
December	10	11	103	.....	.....	500	44,496	312.77	465.43	1,035	644,220	30,000	.....
1898.													
January	.....	21	128	.....	6	.....	287,631	285.39	702.18	875	668,225	40,000	.....
February	2	11	87	.....	.....	.....	156,000	316.91	509.72	888	317,602	72,500	.....
March	.....	51	126	.....	.....	.....	91,500	624.41	895.52	1,531	400,000	24,000	.....
April	.....	351	164	.....	.....	.....	35,000	496.68	767.25	1,331	610,500	40,000	.....
May	.....	62	171	.....	.....	.....	25,000	564.23	720.12	1,556	253,500	20,000	.....
June	.....	3	29	.....	.....	.....	.....	87.62	107.75	370	.....	20,500	.....
Total	35.50	766	1,201	64	22	2,500	860,523	5,654.32	7,942.41	15,961	15,338,863	822,000	32,000

Month.	Bound down.												
	Hay.	Cattle.	Horses.	Sheep.	Miscellaneous Live stock.	Wool.	Berries and fruit.	Lumber.	Miscellaneous merchandise.	Logs.	Total cargo.	Passengers.
1897.	*Tons.*	*No.*	*No.*	*No.*	*No.*	*Lbs.*	*Lbs.*	*Ft. B. M*	*Tons.*	*Tons.*	*Tons.*	*No.*
July	.....	.....	164	475	.....	371,103	17,000	2,400	58.75	.....	408.45	3,115
August	.....	.....	89	1,997	1	187,899	35,655	.....	49.74	31.50	416.77	1,276
September	.....	87	88	985	2	341,845	41,700	.....	60.06	42.75	1,536.63	1,147
October	.....	20	215	1,057	16	.....	5,000	.....	84.19	46.50	3,382.59	1,487
November	1	7	192	.....	133	.....	25,680	6,000	87.54	15.30	2,456.01	1,389
December	.....	4	80	.....	1	.....	2,500	.....	51.02	.....	447.72	1,427
1898.												
January	.....	.....	28	.....	32	.....	.....	.....	48.49	.....	424	935
February	.....	71	101	912	40	.....	3,000	.....	34.46	.....	405.83	649
March	.....	10	119	.....	25	.....	14,000	3,500	182.33	.75	497.06	883
April	.....	2	116	.....	100	.....	1,500	1,000	70.51	.....	485.50	797
May	.....	.....	94	480	40	24,000	.....	12,000	66.93	.....	325.37	1,188
June	.....	.....	84	220	.....	.....	.....	.....	9.00	.....	82.75	231
Total	1	201	1,380	6,126	396	924,847	145,035	27,900	804.02	136.80	10,870.28	14,865

Meteorological and gauge record for the year.

Months.	Rainfall.	Days on which rain or snow fell.	Average temperature at 12 m.	Highest reading of gauges.		Lowest reading of gauges.	
				Head of canal.	Foot of canal.	Head of canal.	Foot of canal.
1897.	*Inches.*		*Deg. F.*				
.....	0.62	3	72.7	117	102.3	108.7	91.5
ust	1.43	3	79.3	108.2	91	105	85.6
ember	4.01	8	66.6	104.7	85.3	99.1	76.5
ber	3.95	11	58.7	99.3	76.7	98	74.3
mber.....	19.24	23	44.4	103.6	83	97.6	74.3
mber.....	19.26	21	38	104.4	84.4	100.3	78.4
1898.							
ary.....	10.53	18	39.2	103.2	82.5	98.1	74.3
uary.....	14.48	23	45	109	91.7	97.9	74.7
h.....	5.56	15	48.9	104.1	84	100	77.9
l.....	3.13	8	58.9	112.5	96.8	99.8	77.5
.....	2.67	11	64.5	123.0	109.8	112.1	96.4
.....	1.83	12	69.8	125.7	111.8	121.2	107.5
Total.....	86.71	156	57.16	.....	.....	.....	.....

eat reading at head of canal during the year..... 125.7
eat reading at foot of canal during the year 111.8
st reading at head of canal during the year 97.6
st reading at foot of canal during the year 74.3

TE.—Reading of adopted low water at head of canal is 96; reading of adopted low water at foot of l is 72.

T T 17.

'ROVEMENT OF COLUMBIA RIVER BETWEEN VANCOUVER, WASHINGTON, AND MOUTH OF WILLAMETTE RIVER.

'he present project, adopted in 1892, consequent to the report nted in the Annual Report of the Chief of Engineers for 1892 (Part , pp. 2866–2869), and extended in accordance with report printed in Annual Report of the Chief of Engineers for 1896 (Part V, pp. 4–3265), provided for constructing a pile, brush, and stone dam about 00 feet long from the Oregon shore to the head of Hayden Island, in Columbia River opposite Vancouver, Wash., at an estimated cost of 00,000.

/ancouver is 103 miles above the mouth of the Columbia River, in Pacific Ocean, and vessels drawing 20 or more feet of water can ily ascend from the mouth of the Columbia to a point 2½ miles below ncouver, where a bar with but 9 feet of water over it is encountered. e object of the dam from the Oregon shore to the head of Hayden and is to stop the flow of water south of the island during low-water ges and deflect it down the main channel north of the island, so as scour the bar below Vancouver and obtain a depth over it sufficient permit vessels drawing 20 or more feet to reach Vancouver.

'he dam provided for in the original project of 1892 had been almost npleted in the spring of 1893, when high water carried the head of island and a portion of the dam away. The top of the original n was 4 feet above low water.

On November 16, 1897, a contract was entered into with John Hale, Portland, Oreg., for furnishing all labor and materials required to ke the necessary repairs to the then existing dam, to construct about 00 feet of dam, with its top about 6 feet above low water, from the

end of the then existing dam to the head of Hayden Island, to construct across the head of the island about 700 feet of cross dams from the new portion of the main dam, and to construct about 800 feet of shore revetment at the head of the island.

Operations were begun by the contractor on December 20, 1897, and were completed on April 9, 1898. The following-named quantities of materials were placed by the contractor:

Piles	linear feet..	44,506
Brush	cords..	5,140½
Stone	tons..	14,809.833
Wire	pounds..	11,800
Sand bags, filled	number..	1,700
Wire rope	linear feet..	4,894
Spikes	pounds..	6,200
Lumber	feet B. M..	49,360
Bolts, with nuts and washers	number..	820

Immediately upon the completion of the work by the contractor the annual rise in the Columbia River set in, and has since prevailed, rendering it impossible to make any examinations with the view of ascertaining what effect the dam has so far had in scouring the bar below Vancouver.

Money statement.

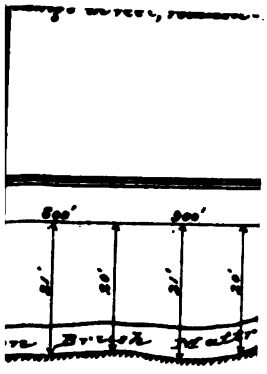
July 1, 1897, balance unexpended	$67,005.20
June 30, 1898, amount expended during fiscal year	25,208.83
July 1, 1898, balance unexpended	41,796.37
July 1, 1898, outstanding liabilities	19.80
July 1, 1898, balance available	41,776.57

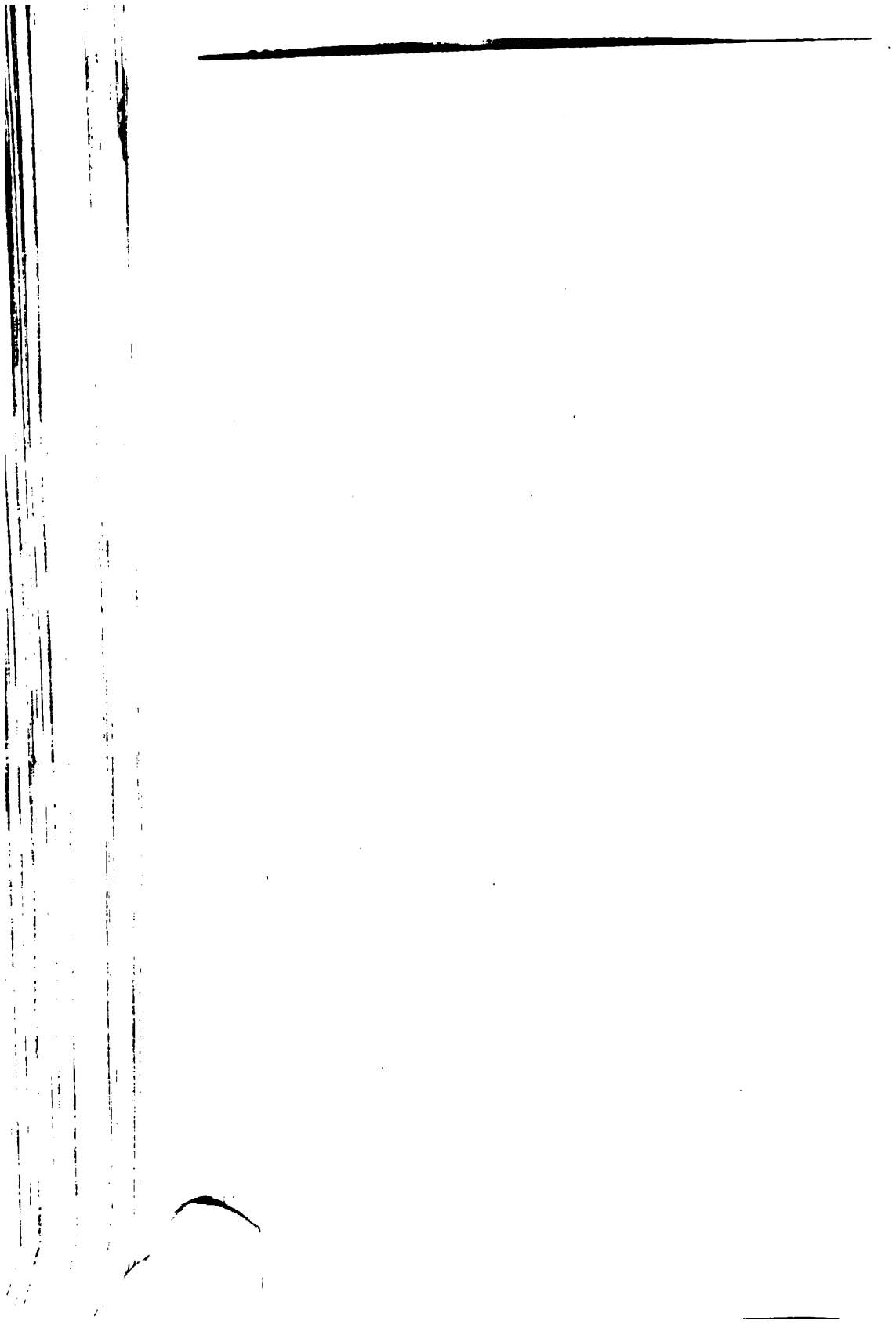
Appropriations.

Act of—	
July 13, 1892	$33,000
June 3, 1896	67,000
Total	100,000

Abstract of proposals for furnishing and placing materials necessary to repair and extend dam, etc., across Hayden Island Slough, Columbia River, received in response to advertisement dated October 26, 1897, and opened at Portland, Oreg., on November 16, 1897, by Capt. W. L. Fisk, Corps of Engineers.

No.	Bidders.	Piles (33,000 linear feet), per linear foot.	Lumber (61,000 feet B. M.), per 1,000 feet.	Spikes (7,500 pounds), per pound.	Bolts, nuts, and washers (755), per bolt, etc.	Brush (5,500 cords), per cord.
1	Nichols & Crothers, Tacoma, Wash	$0.07½	$10.50	$0.03½	$0.14	$1.90
2	Minsinger & Smith, Portland, Oreg	.08½	11.50	.04	.15	1.90
3	Normile & Fastabend, Astoria, Oreg	.10½	11.50	.04½	.18	1.85
4	Wakefield & Jacobsen, Portland, Oreg	.08	10.00	.03	.15	2.25
5	O'Neil & Drew & Co., Portland, Oreg	.12	12.00	.10	.80	1.85
6	G. O. Nolan, Tillamook, Oreg	.25	10.00	.02	.05	4.00
7	Paquet & Nickum, Portland, Oreg	.09	9.50	.02½	.21	2.00
8	John Hale, Portland, Oreg	.10	10.00	.02½	.21	1.75
9	Christensen & Reeve, Portland, Oreg	.08½	8.75	.03½	.19	1.85





stract of proposals for furnishing and placing materials necessary to repair and extend dam, etc., across Hayden Island Slough, Columbia River, etc.—Continued.

Bidders.	Annealed wire No. 12 (11,000 pounds), per pound.	Steel wire rope (4,000 linear feet), per linear foot.	Stone (5,600 tons), per ton.	Sand bags filled (9,000), each.	Total.
Nichols & Crothers, Tacoma, Wash	$0.03	$0.18	$0.60	$0.12	$19,423.70
Minsinger & Smith, Portland, Oreg	.02½	.13½	.55	.15	19,559.75
Normile & Fastabend, Astoria, Oreg	.03½	.29	.65	.14	21,892.40
Wakefield & Jacobsen, Portland, Oreg	.03½	.20	.50	.12	21,000.75
O'Neil & Drew & Co., Portland, Oreg	.08½	.27½	.45	.10	21,281.00
G. O. Nolan, Tillamook, Oreg	.02	.20	.95	.33	40,357.75
Paquet & Nickum, Portland, Oreg	.02½	.30	.60	.13	20,886.30
John Hale, Portland, Oreg	.02⅞	.25	.50	.15	19,286.30
Christensen & Reeve, Portland, Oreg	.05	.30	.59	.24	21,702.45

Proposal of John Hale accepted.

stract of contract in force during fiscal year ending June 30, 1898, for furnishing and placing materials necessary to repair and extend dam, etc., across Hayden Island Slough, Columbia River.

Contractor.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
n Hale	Nov. 16, 1897	Nov. 26, 1897	Dec. 8, 1897	a Mar. 15, 1898

a Extended to April 14, 1898, by authority of Chief of Engineers, dated March 28, 1898.

COMMERCIAL STATISTICS.

This work is in the collection district of Willamette. The nearest port of entry Portland, Oreg., 17 miles distant by river, 5 miles by land. The nearest coast ht-house is at the mouth of the Columbia River, 103 miles distant.

The following statement of traffic on the Columbia River between the mouth of the illamette River and Cascade Locks has been compiled from reports of the various amers and transportation companies doing business on this part of the river ring the calendar year 1897:

	Tons.
nd and gravel	91,500
ain	6,216
ttle and horses	1,648
eep and hogs	763
neral merchandise	13,427
sh	2,842
ool	535
assengers (81,913)	5,463
Total	122,394

T T 18.

IMPROVEMENT OF CLEARWATER RIVER, IDAHO.

This work was in the charge of Capt. Harry Taylor, Corps of Engineers, until November 30, 1897.]

The original project for improvement, adopted in 1879, provided for moving rocks from the channel to obtain a low-water depth of 4½ feet the 40 miles of the Clearwater above its mouth in the Snake River

at Lewiston, Idaho, at an estimated cost of $34,424. (Annual Report of the Chief of Engineers for 1879, Part II, p. 1855.)

Up to and including the act of Congress of August 2, 1882, $15,000 were appropriated for this purpose. No appropriations were made between August 2, 1882, and June 3, 1896.

The act of Congress of June 3, 1896, appropriated $25,000 for "continuing the improvement of Clearwater River."

By letter dated Office of the Chief of Engineers, United States Army, July 23, 1896, Capt. Harry Taylor, Corps of Engineers, was authorized to make a survey of the stream to obtain data upon which to base an estimate of the cost of improving it so as to better meet the requirements of the country. The project submitted in this report, and approved by the Secretary of War on July 23, 1897, provides for improving the stream for high-water navigation, at an estimated cost of $35,000, independent of $15,000 appropriated prior to 1883, but including $25,000 appropriated June 3, 1896.

During the past season operations consisting of blasting by hired labor such rocks as interfered with high-water navigation, from Kamiah, Idaho, about 67 miles above Lewiston, Idaho, down to "Big Eddy," about 27 miles above Lewiston. As it is impossible to tow quarter boats up against the current of the stream, and as work can not be economically conducted without them, each season's operations must be inaugurated by the construction of such boats. On August 8, 1897, the men engaged for the work began the construction of three such boats, 30, 36, and 40 feet long, a short distance above Kamiah. They were completed on August 15, and on August 23 the party began to descend the stream, stopping en route to blast out obstructing rocks. Big Eddy, formerly one of the most dangerous places in the stream, was reached on October 22, 1897, and from that date until February 14, 1898, when continued high water caused operations to be suspended for the season, efforts were confined to removing the obstructing rocks at that place. The work done during the season resulted in considerably lessening the dangers heretofore attending high-water navigation between Kamiah and Big Eddy, and particularly at Big Eddy.

Money statement.

July 1, 1897, balance unexpended		$17,829.17
December 30, 1897, reimbursement for property transferred *		2.00
March 23, 1898, refundment of overpayment †		.50
		17,831.67
June 30, 1898, amount expended during fiscal year		14,380.18
July 1, 1898, balance unexpended		3,451.49
July 1, 1898, outstanding liabilities		73.88
July 1, 1898, balance available		3,377.61
Amount (estimated) required for completion of existing project	10,000.00	
Amount that can be profitably expended in fiscal year ending June 30, 1900	10,000.00	
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations.

Act of—	
March 3, 1879	$5,000.00
June 14, 1880	5,000.00
August 2, 1882	5,000.00
June 3, 1896	25,000.00
	40,000.00
December 30, 1897, reimbursement for property*	2.00
March 23, 1898, refundment of overpayment†	.50
Total	40,002.50

COMMERCIAL STATISTICS.

Two stern-wheel steamboats, the *Lewiston*, tonnage 539.92, and the *Almota*, tonnage 502.35; draft of water, fully laden, 4 feet 6 inches; light, 1 foot 9 inches; owned by the Oregon Railroad and Navigation Company, navigate the 30 or 40 miles of Clearwater River immediately above its mouth at Lewiston when the stream is at a sufficiently high stage.

It has been impracticable to obtain a statement of the commerce handled on the stream during the past year, but it is known that considerable wheat was, as in former years, carried by the steamboats from various points on the lower part of the river down to Riparia, on Snake River, at which point it was shipped by rail to Portland for export to Europe. Warehouses for storing wheat prior to shipment down the Clearwater River are now being constructed at several points above Lewiston.

T T 19.

PRELIMINARY EXAMINATION OF UMPQUA RIVER, BAR AND ENTRANCE, OREGON.

[Printed in House Doc. No. 122, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 2, 1897.

SIR: I have the honor to submit the accompanying report of August 28, 1897, with map,‡ by Capt. W. L. Fisk, Corps of Engineers, of the results of a preliminary examination of Umpqua River, bar and entrance, Oregon, made to comply with requirements of the river and harbor act of June 3, 1896.

The harbor throat proper has a minimum depth of about 30 feet and width of 900 feet at low tide; the average depth on the crest of the bar is seldom less than 13 feet at low water or 19 feet at high water, and no serious obstructions to navigation exist.

Captain Fisk states that any plan with a view to deepening the channel over the bar must of necessity include the construction of at least one high-tide jetty a mile or more in length, and the expenditure this would involve does not seem warranted. He believes that the excellent natural conditions of this entrance, together with the continued good

* Transfer of property authorized by Chief of Engineers, U. S. Army, November 17, 1897.

† Overpayment of 25 cents made on each voucher 54 and voucher 55 for February, 1898, was refunded on March 23, 1898.

‡ Not reprinted. Printed in House Doc. No. 122, Fifty-fifth Congress, second session.

depth upon the bar, are sufficient for the needs of commerce for some time to come, in consideration of which the harbor is deemed by him to be unworthy of improvement by the General Government at the present time. The views of Captain Fisk are concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers, and by me.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., August 28, 1897.

GENERAL: I have the honor to submit herewith the following report of preliminary examination of the "Umpqua River, bar and entrance, Oregon," made in compliance with river and harbor act of June 3, 1896, and letter of Chief of Engineers dated June 16, 1896:

The Umpqua River is the largest stream emptying into the Pacific between the Sacramento and Columbia rivers. It rises in the Cascade Mountains about 120 miles east of the coast, flows in a general northwesterly direction, and empties into the Pacific Ocean about 175 miles south of the mouth of the Columbia River.

The Umpqua River was one of the earliest gateways to the interior of Oregon, and it was through this valley that many of the early settlers and supplies found their way to the mining regions in the southwestern part of the State. The river is navigable only to the head of tide water, a distance of 26 miles, and above this point is little else than a mountain stream of successive shallow rock rapids, gravel shoals, and intervening pools.

The total drainage area of the river and its tributaries is about 4,000 square miles. The region tributary to the Umpqua supports a growth of valuable timber, and the upper valley is broad and fertile and well under cultivation.

On the tidal portion of the river there is practically no arable land, as the valley contracts and the river winds between high hills on either side, hence the industries of the section are confined largely to the production of lumber and canning of salmon.

The small village of Scottsburg, containing about 100 inhabitants, is situated at the head of navigation for river craft, and is the point of transfer from stage to steamer on the route to the mouth of the Umpqua.

Gardiner is the principal town of the Lower Umpqua, and is situated about 8 miles above the mouth at the head of navigation for seagoing vessels.

Gardiner has a population of about 400, and is the manufacturing point of this section, having a sawmill with a capacity of 80,000 feet B. M. per day, a cannery with an output of 10,000 cases per year, and a creamery which in 1895 shipped 40,000 pounds of butter.

Smiths River joins the Umpqua about 1 mile above Gardiner and is the principal tributary of this section.

The Umpqua, above the mouth of Smiths River to the head of navigation, varies in width from 500 feet to one-half mile, and has a depth of from 2 to 20 feet at time of low tide.

From the mouth of Smiths River to the ocean the Umpqua widens out into an elongated bay or tidal estuary, varying in width from three-eighths to 1½ miles and having a minimum depth of about 10 feet at low tide. This bay contains here and there a few marshy islands and quite an expanse of mud flats, bare at time of low water. The last 4 miles of bay are bounded on the east and south by a high rocky shore, a prominent indentation of which forms Winchester Bay, just inside the entrance. On the west and north between the bay and ocean is a broad sand spit mostly bare of all vegetation, about 4 miles in length and 1 mile in width.

A group of sunken rocks, known as "Ork Reef," lies in mid-channel between Winchester Bay and the north spit. This reef is bare at low water, but forms no serious obstruction, as it is well buoyed and the channel to the west is about one fourth mile in width and of ample depth.

The harbor throat proper is 900 feet wide at low tide and has a minimum depth of about 30 feet, while at high water the width between shore lines is one-half mile or more.

On the south side of the entrance is a rocky reef, bare at low tide, which extends a short distance into the channel, but seems no serious menace to navigation.

The crest of the bar lies southwest of the entrance about 1 mile, and though influenced somewhat by ocean storms and river freshets, the average depth thereon is seldom less than 13 feet at low water. The distance between breakers on the bar is about 1,800 feet, and the 3-fathom curve is found about 2,000 feet each side of the crest. At times during the rainy season heavy freshets occur in the river, adding an immense volume of fresh water to the tidal discharge, which is usually more detrimental than beneficial to the entrance in that the increased current scours away the sands of the north spit and deposits the same upon the bar. The mean range of tide on the bar is about 5 feet, or 6.2 feet above the Coast Survey datum of mean lower low water; hence the depth on the crest at mean high water is about 19 feet.

The tidal influence extends almost undiminished for a distance of 26 miles up the Umpqua to the foot of the rapids, and the tidal area of the stretch is about 10 square miles, giving an average discharge at the mouth of about 65,000 cubic feet per second.

No hidden dangers lie off the entrance to the river, and the coast for about 20 miles on either side is a sandy beach, behind which are sand dunes, those to the south of the entrance rising to considerable height, thus forming a conspicuous landfall for vessels.

A first-order light-house is situated on the heights about three-quarters of a mile south of the entrance, and a life-saving station is located on the north spit, about 1 mile above the mouth of the river.

Because of the slight variation in position and depth of this bar the Umpqua River entrance has always been considered one of the safest on the coast, and comparison of the earliest known coast survey of 1854 with that of most recent date shows but little change and confirms this reputation.

Herewith is submitted a sketch of the entrance and bar taken from the last Coast Survey chart made in 1885 and 1886.

The number of coastwise vessels arriving and clearing at this port during the year of 1896 was 81. Of these, 38 were steamers and 43 sailing vessels.

The schooners *Lillie*, *Louise*, *Lucy*, and *Sadie*, of San Francisco, make regular trips to the Gardiner Mill for lumber, and the steamers *Arcata*, *Alice Blanchard*, and *Arago* run to Gardiner occasionally.

The maximum draft of loaded vessels crossing the bar is 14.6 feet.

The stern-wheel steamer *Eva*, draft 2 feet, makes daily trips between Gardiner and Scottsburg, and during the year 1896 carried 2,600 passengers and 1,000 tons of freight.

Steam propeller *Juno*, draft 4 feet, makes triweekly trips up Smiths River from Gardiner to Sulphur Springs, a distance of 18 miles, and during the year 1896 carried 1,490 passengers and 500 tons of freight.

The following statistics of receipts and shipments at the mouth of the Umpqua during the year ending December 31, 1896, have been furnished by the Gardiner Mill Company:

Receipts:		
General merchandise	tons	1,500
Agricultural implements	do	10
Cannery supplies	do	60
Shipments:		
Lumber	ft.	10,000,000
Laths	M.	2,000
Salmon	tons	350
Grain	do	125
Cattle	do	250
Miscellaneous freight	do	58
Estimated value of imports		$108,500
Estimated value of exports		$151,450

Full and definite knowledge of the existing conditions at the mouth of the Umpqua River can not be had without a more detailed examination and survey of the bar and entrance, and no accurate estimate of the cost of improvement can be made at this time. However, any plan with a view to deepening the channel over the bar must of necessity include the construction of at least one high-tide jetty a mile or more in length, and the expenditure this would involve does not seem warranted.

It is believed that the excellent natural conditions of this entrance, together with the continued good depth upon the bar, are sufficient for the needs of commerce for some time to come, and in consideration of this the harbor is deemed unworthy of improvement by the General Government at the present time.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[Third indorsement.]

U. S. ENGINEER OFFICE,
PACIFIC DIVISION,
San Francisco, Cal., September 17, 1897.

Respectfully returned.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 20.

PRELIMINARY EXAMINATION OF ALSEA RIVER, OREGON, FROM HEAD OF TIDE WATER TO UPPER ALSEA VALLEY.

[Printed in House Doc. No. 111, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 1, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated October 5, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, giving the results of a preliminary examination of Alsea River, Oregon, from head of tide water to Upper Alsea Valley, made to comply with the provisions of the river and harbor act of June 3, 1896.

The work of improving this section of the Alsea River, under an appropriation made therefor by the river and harbor act of June 3, 1896, was completed September 14, 1897, and resulted in providing a high-water boat channel varying in width from 20 to 50 feet, clear of obstructions above the plane of low water, which may be run with comparative safety on any ordinary rise.

For the reasons given in the report Captain Fisk is of opinion that the improvement of the river for low-water navigation and the improvement of the river above the head of tide water are not worthy of further action by the General Government.

The views of the local officer are concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers, and by me.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., October 5, 1897.

GENERAL: I have the honor to submit herewith a report of preliminary examination of "Alsea River, Oregon, from head of tide water to Upper Alsea Valley," made in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter dated June 18, 1896.

For a general description of the Alsea River and Valley, attention is invited to a report on a former preliminary examination, dated October 10, 1892, published in House Ex. Doc. No. 53, Fifty-second Congress, second session, and also report of survey and approved project, dated January 1, 1895, published in House Ex. Doc. No. 235, Fifty-third Congress, third session.

The plan recommended in the latter report, providing for the improvement of the river above tide water for high-water navigation, and author-

* Not reprinted. Printed in House Doc. No. 111, Fifty-fifth Congress, second session.

ized by the last river and harbor act, has been carried out during the present season and completed September 14, 1897.

The country adjacent to "The Forks" of the Alsea, distant some 31 miles by river above the head of tide water, may be said to constitute the "Upper Alsea Valley," or the prescribed head of this examination. This stretch of river between "The Forks" and tide water is essentially a mountain torrent, the total low-water slope being nearly 250 feet on an average fall of about 8 feet to the mile.

On the 31 miles of river there were seventeen well-defined rapids, having a fall of from 2 to 5 feet per 100 feet, and about an equal number of lesser riffles, all more or less rugged and menacing even at time of extreme high water, and owing to this perilous condition but little boating has been done upon the river of late years, the farmers preferring to haul by wagon over steep mountain roads rather than take chance of loss by river.

The method of navigation on the river, as described in previous reports, is by means of rough scows 15 to 40 feet in length and 5 to 10 feet in width, having a loaded draft of from 12 to 18 inches. These are loaded at "The Forks" during time of freshets with the produce of the upper valley, such as wheat, flour, bacon, lumber, etc., and floated to Waldport, at the mouth of the river, the run under favorable conditions being made in about ten hours. During time of low water the depth on the rapids of the upper river is from 6 inches to 1 foot, while sections of the lower river practically run dry, presenting series of bare rock ledges with intervening narrow channels, and it is with difficulty that a skiff can navigate the river at such times—hence the improvement of the river for low-water navigation is utterly out of the question.

The work of improvement during the present season has provided a high water boat channel, varying in width from 20 to 50 feet, clear of all obstructions above the plane of low water, which may be run with comparative safety on any ordinary rise, and boatmen accustomed to using the river express themselves as well satisfied with its present condition. Therefore it is believed that the "Alsea River above the head of tide water" is unworthy of further improvement by the General Government.

A map of the river from "The Forks" to head of tide water, upon which is shown the location of principal rapids, is submitted herewith.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., October 7, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 21.

PRELIMINARY EXAMINATION OF YAQUINA RIVER, OREGON, FROM THE TOWN OF YAQUINA TO HEAD OF TIDE, INCLUDING BIG ELK RIVER TO SUNSET QUARRY.

[Printed in House Doc. No. 112, Fifty-fifth Congress, second session]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 1, 1897.

SIR: I have the honor to submit the accompanying report, dated October 15, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, of the results of a preliminary examination of Yaquina River, Oregon, from the town of Yaquina to head of tide, including Big Elk River to Sunset Quarry, made to comply with provisions of the river and harbor act of June 3, 1896.

For reasons given, Captain Fisk is of opinion, which is concurred in by Col. C. R. Suter, Corps of Engineers, Division Engineer, and by me, that these streams are not worthy of improvement by the General Government at the present time.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., October 15, 1897.

GENERAL: I have the honor to submit herewith a report on preliminary examination of "Yaquina River, Oregon, from town of Yaquina to head of tide, including Big Elk River to Sunset Quarry," made in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter dated June 16, 1896.

The town of Yaquina, the lower limit of this examination, is located on the river about 3 miles above the entrance to Yaquina Bay, and the "head of tide" in Yaquina River proper is about 23 miles above this point.

Big Elk River joins the Yaquina about 4 miles below the head of tide and is itself susceptible to tidal influence to "Sunset Quarry," a distance of 4 miles above the confluence.

The river at the town of Yaquina is about one-fourth of a mile wide; at Toledo, 9 miles above, about half that width; at Elk City, near mouth of Big Elk River, only 100 feet in width.

On this stretch of river there are five shoals, having a depth of about 2 feet at time of low tide, but which do not form serious obstructions to navigation, in that the average range of tide at Elk City is about 6 feet; hence ample depth to meet the demand of commerce may be had on them for several hours twice in each twenty-four hours.

Yaquina and Big Elk rivers above their confluence are from 50 to 75 feet in width, each very crooked and shoal, and at points impassable

*Not reprinted. Printed in House Doc. No. 112, Fifty-fifth Congress, second session.

because of snags, and they are believed to be unsusceptible to improvement for navigation except during time of freshet.

"Sunset Quarry," on Big Elk, is only a quarry in name, as less than 50 tons of rock have ever been taken from there, and as this same rock may be found at other points below Elk City, it is thought this quarry will be of little commercial value—at best insufficient to warrant the improvement.

The general character of the land adjacent to Yaquina River is rough and hilly, unsuitable for agriculture, and its principal production is building stone. A large portion of the commerce on the river during the past fourteen years has been that of rock transportation by the United States from quarries near Toledo and Elk City to the jetties at the entrance of the bay. Scows, 30 by 100 by 5 feet draft, have generally been used in transporting the stone, and in all several hundred thousand tons have been delivered and no especial difficulty experienced on the shoals.

The above would seem to indicate that the river in its present condition is sufficiently navigable to meet all demands of commerce, present and prospective, and therefore Yaquina River and its tributaries are not believed worthy of improvement by the General Government at the present time.

Herewith is submitted a sketch of the portion of Yaquina River covered by the examination.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., October 19, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 22.

PRELIMINARY EXAMINATION OF SILETZ RIVER, BAR AND ENTRANCE, OREGON.

[Printed in House Doc. No. 107, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 1, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated August 27, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, giving the results of a preliminary examination of Siletz River,

* Not reprinted. Printed in House Doc. No. 107, Fifty-fifth Congress, second session.

bar and entrance, Oregon, made to comply with the provisions of the river and harbor act of June 3, 1896.

The Siletz River is, for the most part, a shallow mountain stream, emptying into Siletz Bay near its southern end, 1¾ miles from the bay entrance. At the north side of the entrance to the bay is a ledge of soft rock, beyond which extends a sand beach 400 feet to the base of a headland. Other ledges may exist in the channel between the entrance and the bar.

Captain Fisk states that any plan of improvement for widening the entrance to the bay or deepening the channel across the bar would necessarily involve the construction of at least one, and possibly two, high-tide jetties extending seaward one-fourth mile or more, and that the cost of the work would be great, and in view of the limited and uncertain benefits to be obtained, as indicated by existing and prospective conditions at this point, he is of opinion, which is concurred in by the Division Engineer, Col. Charles R. Suter, Corps of Engineers, and by me, that the bay and entrance are unworthy of improvement by the General Government at this time.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., August 27, 1897.

GENERAL: I have the honor to submit herewith the following report of preliminary examination of the "Siletz River, bar and entrance," made in compliance with the river and harbor act of June 3, 1896, and letter of Chief of Engineers dated June 16, 1896:

Siletz Bay is one of the lesser estuaries of the Oregon coast, situated about 90 miles south of the mouth of the Columbia River and 20 miles north of Yaquina Bay.

The bay is 2½ miles in length and from one-fourth mile to 1 mile in width, and is separated from the ocean by a narrow sand spit projecting from the south about one-eighth mile in width. The main axis of the bay is north and south, parallel with the line of the Pacific coast. The bay entrance is at its north end, and is about 350 feet in width at time of low tide, with a general depth of about 18 feet.

The west side of the bay is an abrupt sandy beach, and it is along this shore that the deepest water is found, while the east side at time of low tide is a series of mud flats and tidal sloughs.

The low-water anchorage of the bay is about 300 acres, with an average depth of about 18 feet.

At the north side of the entrance to the bay is a ledge of soft rock, beyond which extends a sand beach 400 feet to the base of the headland, and it is reported that at times the position of the channel shifts in such a manner as to cut away these sands on the north and extend the spit on the south, thus placing the ledge near mid-channel and making the entrance very narrow. Other ledges may possibly exist in the channel between the entrance and the bar.

The crest of the bar at time of examination lay about one-fourth mile westward of the mouth of the bay, and the channel from the mouth to within about 250 feet of the crest was direct and of ample width and had a minimum depth of 18 feet at low tide. The minimum depth on the bar at time of low tide was found to be about 3 feet and the distance across the same between 3-fathom curves about 450 feet.

It is estimated that the opening between breakers at the crest is about 400 feet.

The mean range of tide on the bar is about 6 feet.

The prevailing winds along the coast during the winter season are from the southeast, south, and southwest, and in summer from the northwest, and it is thought probable from observation at other localities that the channel shifts northward in winter and southward in summer.

The Siletz River, after which the bay takes its name, is for the most part a shallow mountain stream, which rises on the western slope of the Coast Range about 16 miles east of its mouth, and following a very circuitous course flows into the bay near its south end 1¼ miles from the entrance. The total length of the river is about 60 miles, and the influence of the tide is felt for about one-third the distance above its mouth.

Two smaller streams, Drift River and Schooner Creek, also flow into the bay near its head.

The Siletz River Valley, having a drainage area of about 300 square miles, lies almost wholly within what was until recently the Siletz Indian Reservation, the lands of which are for the most part now held in severalty by the Indians, who are unable to alienate any portion of their possessions for a period of twenty-five years, and in consequence of this the settlement and cultivation of this valley is much retarded and its industries correspondingly limited. Considerable arable land lies along the lower and middle portions of the river, and adjacent to the head waters the land is well timbered with fir, cedar, spruce, and hemlock, but the prevailing conditions prevent obtaining timber in sufficient quantities to encourage lumber industry on the bay. The only industry near the mouth of the river is that of Kern Brothers's salmon cannery, which is located about 2 miles above the bay. This cannery has a capacity of 300 cases per ten hours, and its output for the season of 1896 was 6,000 cases.

Any plan of improvement for widening the entrance to the bay or deepening the channel across the bar will of necessity involve the construction of at least one, and possibly two, high-tide jetties extending seaward one-fourth of a mile or more, and before any such project can be formulated further examination, together with a complete survey of the bay and bar, would be necessary. The cost of any such work would necessarily be great, and in view of the limited and uncertain benefits to be obtained as indicated by existing and prospective conditions at this point, I am of the opinion that the bay and entrance are unworthy of improvement by the General Government at this time.

A sketch of Siletz River Bay showing the general situation is submitted herewith.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[Third indorsement.]

U. S. ENGINEER OFFICE,
PACIFIC DIVISION,
San Francisco, Cal., September 17, 1897.

Respectfully returned.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 23.

PRELIMINARY EXAMINATION OF HARBOR AT CAPE LOOKOUT, OREGON, WITH A VIEW TO THE CONSTRUCTION OF A HARBOR OF REFUGE, AND THE ESTIMATED COST THEREOF.

[Printed in House Doc. No. 197, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, January 4, 1898.

SIR: The river and harbor act of June 3, 1896, makes provision for a preliminary examination of "harbor at Cape Lookout, Oregon, with a view to the construction of a harbor of refuge, and the estimated cost thereof," and I have now the honor to submit the accompanying report of December 17, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, of the results of the examination thus provided for.

Captain Fisk is of opinion that the proposed harbor of refuge, if constructed, should be located on the north side of the cape, and on the accompanying map is shown a line of breakwater 6,600 feet in length, the seaward end of which is located due north of the end of the cape and the shore end about one-fourth of a mile east of the end of the cape. The approximate estimate of the cost of the breakwater is $10,725,000.

In view of the unsuitable relative position of Cape Lookout for a harbor of refuge, the poor holding ground for anchorage afforded by the hard bottom, and the enormous cost of construction, Captain Fisk is of opinion that the project is not worthy of consideration by the General Government. This opinion is concurred in by Col. Charles R. Suter, Corps of Engineers, Division Engineer, and by me.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 17, 1897.

GENERAL: I have the honor to submit herewith a report on preliminary examination of "harbor at Cape Lookout, Oregon," made "with a

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*Not reprinted. Printed in House Doc. No. 197, Fifty-fifth Congress, second session.

view to the construction of a harbor of refuge, and estimated cost thereof," in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter dated June 16, 1896.

Cape Lookout is one of the principal promontories of the Oregon coast, and is situated in latitude 45° 20′, longitude 124°, 220 miles south of the Strait of Juan de Fuca, 60 miles south of the mouth of Columbia River, and 550 miles north of San Francisco Bay.

The cape projects westward into the Pacific Ocean a distance of nearly 2 miles, and is about one fourth mile in width at its outer end and about 1 mile in width at the mainland.

The southerly side of the cape tends nearly due east and west, and presents an almost perpendicular rock bluff face throughout. For about one-half mile westward from the mainland a rocky beach extends along the base of this bluff, covered with masses of broken rock which have fallen from the cliffs above, and beyond this to the point of the cape the vertical bluffs extend to the water line.

The northerly face of the cape from the shore end bears about south 66° west, and is also generally vertical for some distance above the water line, though it presents a much less rugged appearance than that of the southerly side. This face of the cape between the rock bluffs is varied here and there by steep grassy and timbered slopes, and also a number of narrow gulches which head almost at the southerly face of the cape and finally terminate at the shore line in small bays. A wide sand beech extends westward for over one-half mile along the base of the bluff.

The cape is covered with a heavy growth of spruce, hemlock, and dense underbrush, and its height above the sea varies from about 400 feet at its extreme outer end to 1,000 feet or more at the mainland. The rock on both sides of the cape is basaltic in character, and apparently badly shattered throughout and unsuitable for construction purposes, except as small rubble.

Suitable anchorage depths are found to the north or south of the cape, and upon the accompanying tracing are shown, in feet, the depths as determined by the most recent survey of the Coast and Geodetic Survey.

The bottom, however, in the vicinity of the cape is indicated as hard and rocky, and would be very poor holding ground for an anchorage.

A very noticeable feature in the vicinity of the cape is the entire absence of drift along the beach to the north and the quantities in evidence on the south beach, which indication makes evident the protection afforded the north beach from southerly winds.

The prevailing coast winds during the spring and summer months are, as a rule, from the north and northwest, while for six months or more during the fall and winter they blow almost continuously from the south and southwest, and it is the gales from the latter direction which are most dreaded by mariners and prove most destructive to coastwise shipping.

With this fact in view, it has been thought advisable to locate the proposed harbor of refuge on the north side of the cape, and upon the accompanying tracing is shown, for purpose of estimate, a line for breakwater 6,600 feet in length, the seaward end of which is located due north of the end of the cape and the shore end about one-fourth mile east of same. This location gives a width of entrance of over a mile outside the 25-foot curve, and provides an anchorage of 500 acres or more with depths exceeding 25 feet.

The depth of water on the line of breakwater shown is from 45 feet at the cape to 75 feet at its outer end. The type of breakwater upon

which the estimate below is based is that of a rubble mound, 40 feet in width on top, 20 feet above low water, with a seaward slope of 1 on 3 to a point 25 feet below low water, from thence to the bottom a natural slope of 4 on 5 and a slope on the harbor side of 1 on 1.

The mound to be built largely of quarry rubble obtainable from the adjoining cliffs and capped with concrete blocks ranging in size from 10 to 25 tons and over, a cross section of which is shown upon the accompanying tracing.

The following is an approximate estimate of the cost of the breakwater as above outlined:

2,500,000 cubic yards small rubble, at $1	$2,500,000
500,000 cubic yards large rubble, at $4	2,000,000
525,000 cubic yards concrete blocks, at $10	5,250,000
Engineering and contingencies, 10 per cent	975,000
Total	10,725,000

After a careful examination of the available data in connection with this examination, the following objections to the construction of a harbor of refuge at this point present themselves: First, the unsuitable relative position of Cape Lookout for such a purpose; second, the poor holding ground for anchorage afforded by the hard bottom surrounding the cape; and, lastly, the enormous cost of construction made necessary by the great depth of water and length of breakwater required for proper protection.

In view of these facts, I am of the opinion that the project for constructing a harbor of refuge at Cape Lookout is unworthy of consideration by the General Government.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., December 22, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 24.

SURVEY OF PORT ORFORD HARBOR, OREGON.

[Printed in House Doc. No. 247, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 20, 1898.

SIR: I have the honor to submit the accompanying copy of report of January 7, 1898, with map,* by Capt. W. L. Fisk, Corps of Engineers,

* Not reprinted. Printed in House Doc. No. 247, Fifty-fifth Congress, second session.

of the results of a survey of Port Orford Harbor, Oregon, with estimate of cost of improvement and importance to shipping and commerce, made to comply with requirements of the river and harbor act of June 3, 1896.

The harbor has been reported upon heretofore with reference to its use as a harbor of refuge, and it is assumed the present report is intended to deal solely with the commercial side of the question.

Quoting from a previous report of January 30, 1895, by Capt. T. W. Symons, Corps of Engineers, Captain Fisk gives a statement of the commerce of Port Orford in detail, and states that while there may be a little more commerce now than at the time covered by those statistics, it will be seen that it is at present utterly insignificant when considered in connection with the very large sum required to adequately protect the harbor from storms, estimated by a Board of Engineers, in report of November 19, 1890, to be $7,821,960 (printed in Annual Report, Chief of Engineers, 1891, p. 3310).

It is the opinion of Captain Fisk, concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers, that, for reasons stated, Port Orford Harbor is not worthy of improvement by the United States.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., January 7, 1898.

GENERAL: I have the honor to submit the following report of survey of Port Orford Harbor, Oregon, in compliance with river and harbor act of June 3, 1896, and the Chief of Engineers' letter dated September 5, 1896:

The act calls for survey of "Port Orford Harbor, Oregon, with estimate of cost of improvement and importance to shipping and commerce."

This harbor has been reported upon so many times with reference to its use as a harbor of refuge that it is assumed the present report is intended to deal solely with the commercial side of the question.

So many different surveys have also been made that all necessary data were available, and it was only deemed necessary to visit Port Orford to see how its present prospects compared with those existing at the time of the last report thereon, viz, that of January 30, 1895, by Maj. Thomas W. Symons, Corps of Engineers. The map herewith has been compiled from previous surveys and is believed to be sufficiently accurate.

Port Orford Harbor is an open roadstead on the Oregon coast, about midway between San Francisco and the Straits of Juan de Fuca. It is simply an abrupt indentation of the coast, the projecting headland giving excellent protection from northerly and northwesterly winds, but leaving it entirely open to the south and southwest, the directions from which come all the severe storms.

In order to be of any real value to commerce the harbor should be accessible at all times, and sufficiently protected to allow shipping to load or unload at the wharves without delay on account of weather.

The Board of Engineers of 1890, which reported upon this place as a harbor of refuge, makes the following statement (Annual Report, Chief of Engineers, 1891, p. 3309):

The area protected by the designed breakwater, 224 to 316 acres outside the 3-fathom curve, is the very least which the Board can recommend. If, instead of being considered a harbor of refuge, it be considered a harbor of commerce, the area is still the minimum which can be recommended.

To obtain this protection the Board estimated would cost $7,821,960.

As the United States has never, to my knowledge, undertaken to build and maintain wharves for purely commercial purposes, it is assumed there is no intention of doing so at this place, and no estimate for that purpose is included here.

As to the importance of the commerce of Port Orford, it can be judged by the following extract from Major Symons's report of January 30, 1895, above referred to. Speaking of Port Orford, he says:

It is located in Curry County, Oreg. This county had a population in 1890 of 1,500. It is increased, probably, to from 2,000 to 2,500. There are about 2,000 square miles in the county, the assessed valuation of which last year, for purposes of taxation, was $772,423. At the last election there were cast 527 votes.

The village of Port Orford is located on the bluff, overlooking the open water to the south, and has a population of perhaps 200 souls. The existing buildings of the village are shown on the map herewith.

There is a daily stage along the coast, connecting Port Orford with the world. There is a regular steamer line that touches here, and other steamers come at irregular intervals.

Industries of Port Orford.—The following list shows commercial industries of the place:

1 daily stage line, with post and express office.
2 hotels.
1 general merchandise store.
1 feed stable.
1 drug and commission store.
1 newspaper.
1 carpenter shop.
1 blacksmith and wagon shop.
1 boot and shoe shop.
1 church.
1 school.
1 saloon.
1 small sawmill with a capacity of 10,000 feet B. M. per day.

In the vicinity of Port Orford there is a large body of fine timber land. This comprises over 100 square miles, covered with fir and cedar, embracing, it is said, the largest body of white or Port Orford cedar on the Pacific coast.

Black-sand mining is carried on along the coast in the vicinity of Port Orford, and there are some quartz and placer mines on Sixes River to the north and east.

One of the principal industries of the country is cattle raising and dairy farming; there is said to be about 120 tons of butter annually produced in the vicinity of Port Orford.

The village of Denmark, 12 miles north of Port Orford, consists of a hotel, a blacksmith shop, and a cooper shop.

The village of Dairyville, 15 miles north, has a general merchandise store, a harness shop, two hotels, one stable, a sawmill, a cooper shop, a blacksmith shop, and three creameries.

To the south of Port Orford, the village of Mussel Creek consists of one hotel, and the village of Euchre Creek has a general merchandise store, a hotel and feed stable, a sawmill, and a wharf and tan-bark depot.

COMMERCIAL STATISTICS.

	Tons.
Imports (general merchandise):	
1891	330
1892	260
1893	280
1894	517
Exports (1894):	**Value.**
Butter, 82 tons, at $440	$36,080
Wool, 67 tons, at $160	10,720
Merchandise, 70 tons, at $50	3,500
Bacon and lard, 6 tons, at $240	1,440
Eggs, 27 tons	680
Hides, 49 tons, at $40	1,960
Chittim bark, 3 tons, at $100	300
Machinery, 105 tons, at $10	1,050
Cedar lumber, 300 M, at $30	9,000
Total	64,730

During 1894 there were 45 arrivals and departures at Port Orford of steamers. The statitics at my disposal do not show that the port has been visited by any sailing vessels for a number of years.

There are now two small sawmills instead of one, but neither was running at the time of my visit in August, 1897.

I have been unable to get later figures, but while there may be a little more commerce now than at the time covered by the above statistics, it will be seen that it is utterly insignificant when considered in connection with the very large sum required to adequately protect the harbor from storms.

The importance to shipping and commerce of a harbor of refuge at Port Orford has been so exhaustively considered in the various reports upon that subject that there seems nothing further to say.

The present wharf accommodation is more than ample for all the commerce now existing or likely to exist for many years to come. Owing to the extreme exposure of the site, I do not think the estimate of $7,821,960, submitted by the Board of 1890 for the protection of the harbor, can safely be reduced to any appreciable extent.

Owing to the very small value of the commerce, present and prospective, as compared with the enormous cost of adequately protecting the harbor, I am of the opinion that Port Orford Harbor is not worthy of improvement by the United States.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., January 10, 1898.

Respectfully forwarded to the Chief of Engineers, United States Army. I concur in the views expressed by the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 25.

SURVEY OF TILLAMOOK BAY, BAR AND ENTRANCE, OREGON.

[Printed in House Doc. No. 217, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, January 10, 1898.

SIR: I have the honor to submit the accompanying report of December 21, 1897, with map*, by Capt. W. L. Fisk, Corps of Engineers, of the results of a survey made of Tillamook Bay, bar and entrance, Oregon, to comply with provisions of the river and harbor act of June 3, 1896.

Captain Fisk states that—

It is believed that the development of Tillamook Bay commerce is in no way hindered by the present condition of the bar and entrance, in that any vessel that can navigate the bay will find no difficulty in crossing the bar. The bay is being improved to as great an extent as natural circumstances will permit, and it is believed that the present efforts of the Government should be confined to this improvement, as outlined in the approved project.

The views of the local officer are concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers.

The estimate of cost submitted by Captain Fisk for improvement of the bar and entrance is $1,200,000.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 21, 1897.

GENERAL: I have the honor to submit herewith a report on the survey of "Tillamook Bay, bar and entrance, Oregon," made in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter, dated September 5, 1896.

Tillamook Bay is situated on the west coast of Oregon, about 47 miles south of the mouth of the Columbia River, and is one of the best of the lesser harbors of the State.

The general description of Tillamook Bay, bar and entrance has been fully set forth in reports already published on this subject, and in this connection attention is respectfully invited to the Report of the Chief of Engineers for 1892, pages 2742–2752.

Upon the accompanying tracing are shown the results of a survey made during September of the present year by J. G. Holcombe, assistant engineer. Very stormy weather prevailed during the time of survey, thus making the development of the bar difficult in the extreme, and while the minimum channel depth obtained on the crest was 13 feet, it is believed, had greater development been possible, that a foot or two

*Not reprinted. Printed in House Doc. No. 217, Fifty-fifth Congress, second session.

less depth would have been found. It is thought safe to assume the minimum low-water depth on the crest to range from 10 to 12 feet, or 16 to 18 feet at mean high water.

The crest of the bar at time of survey lay about 1⅞ miles due west from the harbor throat, and the connecting channel was generally direct and of ample width and depth.

It is said that the influence of the fall and winter gales from the southwest shifts the position of the channel on the bar about one-fourth mile northward of that shown upon the accompanying map, and that the northwesterly summer winds move it a corresponding distance to the southward, making the extreme range of channel on the crest about one-half mile.

The bar drops off very abruptly to the west of the crest and the distance across it between 3-fathom curves is about 3,000 feet, two-thirds of the distance being on the inside of the crest.

The harbor throat proper between the base of "Green Hill" and Kincheloe Point is 1,250 feet wide at mean high-water line, while between 3-fathom curves it is 750 feet wide and has an average low-water depth of 40 feet and maximum depth of 60 feet. The bay inside the entrance soon shoals and a depth of only 8 feet is found in the main channel about 3,500 feet from the harbor throat, and less than half this depth can be obtained on some of the shoals between this point and Tillamook City, at the head of the bay.

Tillamook Bar has always been considered by mariners as one of the safest along the coast on account of its generally uniform depth and position, and no wreck is known to have ever occurred in crossing it.

The following statistics of receipts and shipments at Tillamook Bay, during the calendar year ending December 31, 1896, are quoted from my last annual report:

	Tons.
Receipts:	
General merchandise	6,600
Agricultural implements	740
Flour and feed	730
Shipments:	
Lumber (11,000,000 feet)	16,500
Butter	450
Eggs	46
Salmon	455
Cheese	416

The number of vessels arriving at and clearing from the bay during the year was 114, all steamers. Maximum draft of loaded vessels, 13.5 feet.

It is believed that the development of Tillamook Bay commerce is in no way hindered by the present condition of the bar and entrance, in that any vessel that can navigate the bay will find no difficulty in crossing the bar. The bay is being improved to as great an extent as natural circumstances will permit, and it is believed that the present efforts of the Government should be confined to this improvement, as outlined in the approved project.

* * * * * * *

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., December 27, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 26.

SURVEY OF NEHALEM RIVER BAY, OREGON, FOR MODIFIED PLAN.

[Printed in House Doc. No. 236, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 14, 1898.

SIR: I have the honor to submit the accompanying copy of report of December 29, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, of the results of a survey of Nehalem River (Bay), Oregon, for modified plan, made to comply with requirement of the river and harbor act of June 3, 1896.

A project for improvement of entrance to Nehalem Bay, which provided for the construction of two high-tide stone jetties extending seaward a sufficient distance to secure a permanent low-water depth of 8 feet on the bar, was adopted by the river and harbor act approved September 19, 1890, the sum of $10,000 being made available for commencement of jetty construction. No work was done toward carrying out the project, owing to lack of funds.

The modified plan asked for is construed by local residents to mean the construction of a single jetty, which they believe if placed on the south side will confine the channel to a fixed position, and a plan for such a jetty has been carefully considered by Captain Fisk, but for reasons stated it is thought hardly probable that a single jetty would bring about the results desired.

A project is therefore presented which contemplates the construction of two jetties at the north location, estimated to cost, including tramways, plant, and contingencies, $610,500.

The cost of a single south jetty is estimated to be, including contingencies, plant, and tramway, $582,000.

Captain Fisk states, however, that while it is quite possible future developments may render advisable the improvement of the entrance to Nehalem Bay, it is not, in his opinion, at present worthy of improvement by the General Government, and his views are concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

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*Not reprinted. Printed in House Doc. No. 236, Fifty-fifth Congress, second session.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 29, 1897.

GENERAL: I have the honor to submit herewith a report on survey of "Nehalem River, Oregon," together with "modified plan" for improvement of same, made in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter, dated September 5, 1896.

The entrance of Nehalem River, or more properly Nehalem Bay, has, since 1876, been the subject of six reports, three of which have included the results of instrumental surveys; consequently, the general and historical descriptions having been fully set forth (see Report of Chief of Engineers, 1876, pp. 639–641; 1885, 2409–2413; 1887, 2496–2498; 1890, 2992–2999; 1891, 3205–3210, and 1892, 2703–2709), they are not again gone into in this report.

As stated in the last report on this subject (Chief of Engineers' Annual Report, 1892, pp. 2703–2709), Nehalem Bay at high water is about 2 miles long by 1⅛ miles wide at widest part, and is connected with the ocean by a narrow channel, extending in a southerly direction about 3 miles This channel varies in width from about 1,000 to 2,000 feet at high tide. A low, sandy peninsula, 2½ miles long and one-fourth mile wide, lies to the west of this channel and separates it from the ocean. The southern end of this peninsula forms the northern shore of the entrance, and the distance between this and the main shore on a north-and-south line is about 1 mile. The entrance channel shifts within the limit of this mile, occupying sometimes a southerly position and sometimes a northerly one, and at times there are two channels, separated by a sand flat, bare at low tide.

The survey of 1889 shows the channel in its northerly position, that of 1891 in its most southerly position, and at the time of the last survey it was found in an intermediate position.

The conclusion reached in all previous examinations has been that there is no regular cycle of change in these channels, but that any heavy storm is liable to shift the entrance channel to any point from its northerly to its southerly position. However, the observations since 1891 of those living near the entrance would seem to indicate that this is not the case.

The channel is said to be at its best when in its most northerly position, at which time its course is nearly due west, or straight out to sea, and a depth of about 8 feet is then found on the crest of the bar. This position gradually shifts to the southward, caused by the north sand spit growing to the south under action of northwest winds, and the channel to the east of the bar then assumes the shape of a U, but the position of the crest and channel beyond remain about as before until the inner channel has shifted over a half mile southward; then the channel on the bar changes and the general course to the sea is about southwest.

The inner channel continues to shift southward until it is forced against the bluff, its southern limit, and in this position it is said to have least depth and be most difficult to navigate, in that vessels when entering are placed broadside to the sea. The above movement of the north spit is attributed to the northwesterly winds which prevail during the summer and fall months, but when the winter storms from the southwest begin, the channel in its southerly position is filled with sand, and in a few days it breaks through the sand spit at its most northerly position and the movement southward is again resumed.

On March 9 of the present year the channel over the bar was in its most southerly position, and on this date the tug *Occident* passed out and found a straight and well-defined channel of ample depth. In attempting to return on this same course three days later, she struck, went to pieces, and was a total loss, the channel in the meantime having shifted to its northerly position.

Accompanying this report is a tracing upon which is shown the results of a recent survey made during August of the present year by J. G. Holcombe, Assistant Engineer. The channel at this time was in its intermediate position, and a minimum depth of 8 feet was found on the bar. Stormy weather prevailed throughout the entire time of survey, and but few lines could be run with safety over the crest of the bar; however, it is believed to have been sufficiently developed for the purpose intended.

The plan of improvement outlined in the project as submitted in the Annual Report for 1892 includes the construction of two high-tide stone jetties extending seaward on nearly parallel lines to such a distance as will secure a permanent low-water depth of at least 8 feet on the bar, the exact location and length to be determined at the time of construction.

The "modified plan" asked for in the last act is construed by the residents of Nehalem to mean the construction of a single jetty which, they believe, if placed on the south side, will confine the channel to one position, it being their desire to secure a fixed channel rather than an increase of depth upon the bar.

The plan of a single jetty has been carefully considered, but it is thought hardly probable that such would bring about the results desired, in that two distinct elements—the continuous sand movement from the north spit and the direction of the inner channel of the river—unite in forcing the entrance to the southward, and each of these must be controlled.

In my opinion the objection to a south jetty alone is the probability of diminishing the depth on the bar by reducing the scouring force of the current at that point by forcing it to continually carry out the sands crowded in from the north spit. It seems to me the most important point in this problem is to remove the cause of this shifting by arresting the movement of the north sands by a jetty on the north side of the desired position of the channel; this being constructed, it might and probably would also be necessary to construct enough south jetty to guide the channel to the new position. An objection to this plan is that the projection of the north jetty beyond the end of the south jetty would have a tendency to guide southwest storm waves into the harbor, but as the nearest wharf is about 4 miles from the bar, it is probable little trouble would be caused. It might prove necessary to extend the south jetty as far westward as the north jetty, but this would be decided by results after completion of the work suggested above.

Upon the accompanying tracing two lines of jetty are shown, the position being practically the same as that outlined for "north location" in the project of 1892, and the estimates herewith are based upon such position.

In making the following estimates the jetties are planned to be rubble mounds upon a brush-mattress foundation, the mounds to be carried to a height of 10 feet above low water, with a top width of 10 feet, and with side slopes ranging from 1 on 3 from top to low water, and then 4 on 5 to the bottom at extreme seaward end, to 1 on 1½ and 1 on 1 at land end, according to position, exposure, and depth of water.

ESTIMATE.

[North jetty, approximate length, 3,200 feet; tramway approach, approximate length, 1,300 feet.]

3,200 linear feet tramway, double track, at $5 per linear foot	$16,000
1,300 linear feet tramway approach, at $4 per linear foot	5,200
3,200 linear feet mattress work, at $4	12,800
125,000 cubic yards enrockment, at $1.50 per cubic yard	187,500
Total	221,500

[Short south jetty, approximate length, 3,000 feet; approach from quarry, approximate length, 3,000 feet.]

3,000 linear feet tramway, double track, at $5 per linear foot	$15,000
3,000 linear feet tramway approach, at $3 per linear foot	9,000
3,000 linear feet mattress work, at $5 per linear foot	15,000
170,000 cubic yards enrockment, at $1.50 per cubic yard	255,000
Total	294,000

Total north jetty	221,500
Total south jetty	294,000
Plant, buildings, wharves, etc	40,000
Engineering, contingencies, etc	55,000
Total for project	610,500

In the above estimate it is assumed that the sand will scour away in front of the south jetty during construction, and the mattress is estimated as laid in an average depth of 20 feet below low water.

For the purpose of comparison the following estimate is submitted on the south jetty continued beyond the crest of the bar:

ESTIMATE.

[Single south jetty, approximate length, 4,500 feet; approach from quarry, approximate length, 3,000 feet.]

4,500 linear feet tramway, double track, at $5 per linear foot	$22,500
3,000 linear feet approach, at $3 per linear foot	9,000
4,500 linear feet mattress work, at $5 per linear foot	22,500
290,000 cubic yards enrockment, at $1.50 per cubic yard	435,000
Plant, buildings, wharves, etc	40,000
Engineering, contingencies, etc	53,000
Total	582,000

The country tributary to the Nehalem River is essentially a timber district, and, as has been stated in previous reports, the only justification for the improvement of the bar and entrance is the benefit which it would afford the lumber industry by furnishing a harbor from which this product might be shipped to market.

No official statistics of the commerce of Nehalem Bay have been received for the present year, and the only available data as to lumber exports were secured during time of survey from Himple & Wheeler, mill men, for the months of August and September, 1897. During this period they shipped 15 schooner loads of lumber, each averaging 160,000 feet B. M., or a total of 2,400,000 feet B. M., for sixty days.

The channel over the bar at this time was about in the condition shown upon the accompanying tracing, the best known for several years, and such condition made the above named shipments possible; however, they must be regarded as greater than the general average.

The following report of annual imports and exports has been fur-

nished by the citizens of Nehalem, and it is probable that the quantities given therein are not underestimated:

The exports of the lower 15 miles of the river consist of 15,000 cases of salmon, which, at $3 per case, would equal $45,000. Other valuable varieties of fish, clams, etc., are available, but no industries so far have been established for preparing them for the market; 2,500 head of beeves are annually sold to the market; 150 tons of butter, worth $60,000; honey, cheese, eggs, hay, potatoes, etc., of an amount we are not able to state.

Five thousand tons of merchandise are brought in annually.

Of the above exports and imports (except salmon industries, which are exclusively on the bay) about one-fourth come over the bar at present.

While it is quite possible future development may render advisable the improvement of the entrance to Nehalem Bay, it is not, in my opinion, at present worthy of improvement by the General Government.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., January 3, 1898.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

T T 27.

SURVEY OF SNAKE RIVER, WASHINGTON, FROM ITS MOUTH TO RIPARIA.

[Printed in House Doc. No. 411, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., April 5, 1898.

SIR: I have the honor to submit the accompanying report, dated January 27, 1898 (with map in four sheets*), by Capt. Harry Taylor, Corps of Engineers, giving the results of a survey of Snake River, Washington, from its mouth to Riparia, made to comply with the provisions of the river and harbor act of June 3, 1896.

The plan of improvement presented contemplates the removal of rock ledges and bowlders, the scraping of cobblestone bars, and the building of contraction works wherever necessary, with a view to giving a channel with a minimum depth of 5 feet at low water. The cost is estimated at $165,000, and is based upon the assumption that appropriations will be sufficient to permit of a suitable plant being provided and worked at an efficient rate.

With a free channel once obtained there will still be considerable work necessary to keep it clear of bowlders which are annually brought

* Not reprinted. *Printed in House Doc. No. 411, Fifty-fifth Congress, second session.*

down by ice and high water and lodged on shoals and rapids. It is estimated that the removal of these obstructions will require an expenditure of $3,000 every two years.

In transmitting the report to this office Captain Taylor expressed the opinion that the project submitted is the best that can be devised at the present time, but that from past experience it appears that this section of the river is particularly difficult to improve, and that at present there is practically no navigation nor local commerce to be benefited, and that no navigation can be developed as long as the Columbia River is impassable for boats at The Dalles, and the other means of transportation in this section of the country remain as at present.

In forwarding the report the division engineer, Col. Charles R. Suter, Corps of Engineers, expressed the view that, in his opinion, the low-water improvement of a stream with such a heavy slope, beyond the removal of rocks and bowlders, is entirely impracticable except by a more radical method than that of open-channel improvement.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., January 27, 1898.

GENERAL: I have the honor to submit the following report of a survey of the Snake River, from its mouth to Riparia, Wash., made in compliance with the requirements of the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The Snake River takes its rise in the southern part of Yellowstone National Park, very near the head waters of the Madison Fork of the Missouri and the Green River branch of the Colorado, the former flowing into the Gulf of Mexico and the latter into the Gulf of California. From its source the Snake takes a southwesterly course until it comes within 60 miles of the present limits of the Great Salt Lake of Utah. From the vicinity of the Great Salt Lake it takes a northwesterly course across Idaho to the Idaho-Oregon boundary line, where it turns to the north and forms the boundary between those States for about 200 miles. At Lewiston it turns again and follows a general westerly direction for about 140 miles to its confluence with the Columbia.

Through southern Idaho the Snake River flows in a tremendous canyon, in which are numerous rapids and falls of great magnitude and beauty, ranking with Niagara and the falls of the Zambesi, in Africa. The principal are the great Shoshone Falls, the American Falls, and Salmon Falls. A number of streams flow into the Snake from the south and west, among which the principal are the Bruneau, Owyhee, Malheur, Burnt, Powder, and Grand Ronde rivers. The main branches from the east are the Malade, Boise, Payette, Salmon, and Clearwater. Nearly all the streams flowing into the Snake may be characterized as mountain torrents flowing through deep canyons, entirely unnavigable, and with very little valley land along their courses.

The Snake River from Lewiston to its mouth flows through a deep, narrow valley, with precipitous slopes, broken frequently at or near the river by vertical walls of columnar basalt. These slopes are surmounted by a heavily rolling plateau extending back into the interior. As the river is descended the elevation falls until Ainsworth is reached, near the mouth of the river, where the plateau is about 40 feet above low water. On both banks of the river at frequent intervals are to be found high rolling benches at the foot of the steep slopes of the main valley. The cultivated area in the valley is confined to these benches. With thorough irrigation some of these produce extraordinary yields of fruit.

The plateau near the river has proven too dry for grain, but at a distance of 6 or 7 miles back from the river, on each side, it is better adapted for raising these crops, and it is all taken up under the homestead laws.

Below Riparia there are a few orchards scattered along the river at infrequent intervals, most of them being near Fords Island. The products of these orchards are shipped to market over the Oregon and Washington Territory Railroad, which parallels the river on the south side at an average distance of 6 miles. The great fruit-raising section of the Snake River is above Riparia.

The country lying to the north of the section of the river between Riparia and the mouth is tapped by the Palouse branch of the Northern Pacific Railroad, which is separated from the river by the high country intervening, and nowhere approaches it nearer than 4 miles.

The Oregon Railway and Navigation Company's railroad, from Wallula to Spokane, follows down the valley of Tucannon Creek to the Snake River, and up the left bank of the Snake to Riparia, where it crosses and then passes up the valley of Alkali Creek to the country north of the river.

On the hills flanking the lower part of the river large bands of sheep find winter pasture. The wool is usually shipped by boat to Riparia during high water. Thousands of horses range on the plateau on the north side. These are allowed to run wild, and are not at present a source of revenue.

The ground near the river, especially toward the mouth, is sandy and supports a heavy growth of sagebrush and weeds, which gradually give place to a light growth of bunch grass on the high plateau. There is no timber. On some of the bars are found thickets of willows, which rarely attain a height of more than 12 feet.

The whole number of residents along the stretch of river below Riparia does not exceed 50.

There are but two tributaries to the Snake River between Riparia and the mouth—Tucannon Creek and Palouse River. Tucannon Creek empties into the Snake from the south 5 miles below Riparia. This stream has a low-water width of about 30 feet and carries but little water except at flood seasons. It drains an area of about 360 square miles. Palouse River is a small, rapidly falling stream, emptying into the Snake about 7½ miles below Riparia. It has a low-water width of about 40 feet, and with all its tributaries drains an area of approximately 2,380 square miles. The drainage area of the Snake itself, between Riparia and its mouth, is 510 square miles, making in all 3,250 square miles directly tributary to this portion of the river. This area, being very small in comparison to the total drainage area of the Snake, and being also extremely dry, the volume of the river remains practically the same from Riparia to its mouth.

The Snake River and its many branches drain all of Idaho except a small portion in the north, the eastern part of Oregon, the southeast corner of Washington, and small parts of Wyoming, Utah, and Nevada. The areas in these States draining into the Snake River are approximately as follows:

	Square miles.
Washington	5,200
Oregon	17,200
Idaho	70,040
Wyoming	5,120
Utah	760
Nevada	6,280
Total	104,600

This is an area almost equal to that of all the New England States and New York combined.

At low water the Snake River discharges into the Columbia about 26,000 cubic feet per second. The period of high water in the Snake ranges generally from April 1 to August 1. This high water is caused by the melting of the snow in the mountains at the head waters of the Snake and its tributaries. There is usually a fall rise in the month of November, caused by heavy rains which generally fall in that month. On May 26, 1897, the river was 19.3 feet above extreme low water on the gauge kept by the Oregon Railway and Navigation Company at Riparia. At other points on the river the stage was from 18 to 26 feet above low water, depending upon the width of the river. This was somewhat higher than the average summer rise. The fall rise is usually from 4 feet to 10 feet above low water.

At the present time the only part of the Snake River system which is being regularly navigated is that part of the Snake River between Riparia and Lewiston. Asotin, 7 miles above Lewiston, is generally considered the head of navigation of this stretch of river, and boats go that far whenever there is any occasion for them to do so. In former years they have gone up the Snake as far as the Grand Ronde River, 30 miles above Lewiston, and have also gone up the Clearwater 69 miles to Kamiah.

Before the railroads which now parallel the Columbia and Snake rivers were built these streams were the great highways of travel, and played a very important part in the settlement of the section of country though which they flow. Congress early recognized the importance of the improvement of these streams, and in the act of June 10, 1873, made an appropriation of $50,000 for the improvement of the Columbia River from Celilo, Oreg., to the mouth of the Snake. During the two succeeding years an additional amount of $55,000 was appropriated for this stretch of river. In the year 1876 the Snake River, from Lewiston to its mouth, was added, and in 1892 the upper limit of the improvement was extended to Asotin, 7 miles above Lewiston.

The total amount appropriated for the improvement of the "Upper Columbia and Snake rivers, Oregon and Washington," as the improvement of the continuous Columbia and Snake rivers from Celilo, Oreg., to Asotin, Wash., is designated, has been $231,000. Of this amount, $110,350.57, as nearly as can be ascertained from the records, had been spent on the part of the Snake River between Riparia and its mouth; that is, the part included in this survey prior to 1889. No work has been done in this section of the river since 1888, as the appropriations for the improvement of the "Upper Columbia and Snake rivers" have

been small and the interests of commerce have demanded that all of these small appropriations be spent on other parts of the Snake River, where there was some regular navigation to be benefited.

It is possible that, when the Columbia River is opened at The Dalles so that boats can pass from the Lower Columbia to the mouth of the Snake without transfer of cargo, this part of the Snake may again assume an important relation in regard to the commerce of this section of the country, but until that time comes there does not appear to be any prospect of its again exercising much influence on the development of the country. The railroads have robbed it of its importance, and until such time as it may become part of a through system of navigation from tide water to the vicinity of the rich wheat country in eastern Oregon, eastern Washington, and Idaho, it can never regain its importance. The local traffic along this section of river is small and, owing to the proximity of the railroads on each side and other causes, must always remain so.

The results of the work done have been to remove many obstructions to navigation and render somewhat less dangerous the greater part of the rapids and shoals on this stretch of river. But if it is contemplated to so improve the river as to render it navigable at low water a great deal of work remains to be done; and as the river has already been improved so that there are practically no obstructions to navigation at high water except the swift current due to the great fall of the river, which is 201.8 feet at low water between Riparia and the mouth, a distance of 66.7 miles, it is inferred that a project for its improvement to permit a low-water navigation is desired.

It appears at the present time that this improvement can be effected at a cost of $165,000, this estimate being based on the cost of the work which has been done in the past, and it being assumed that the appropriation will be large enough to permit of a suitable plant being provided and worked at an efficient rate.

This project contemplates the removal of rock ledges and bowlders, the scraping of cobblestone bars, and the building of contraction works wherever necessary, so as to give a free channel with a minimum depth of 5 feet at low water. The work to be done at the various rapids and shoals is described in detail in the appended "Description of Rapids and Shoals."

With a free channel once obtained, there will still be considerable work necessary in order to keep it clear of bowlders, which are annually brought down by ice and high water and lodged on shoals and rapids. These form annually recurring obstructions, and will probably require the expenditure of $3,000 every two years to remove.

Appended hereto is a tabulated list of rapids, shoals, and prominent points between Riparia and the mouth of the river and a detailed "description of rapids and shoals," giving the amount of work yet to be done at each and the amount of work which has heretofore been done. Until 1885 the work was done by contract and after that by hired labor. The average cost of the rock removed by contract was $18.79 and the average cost of that removed by hired labor was $5.11.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

SNAKE RIVER, WASHINGTON.

Tabulated list of rapids, shoals, and prominent points.

Locality.	Distance from Riparia.	Distance from mouth of river.	Elevation of water surface.	Fall of water.	Rate of fall per mile.
Riparia	0.00	66.70	516.25	.....	.....
Texas Rapids:					
Head	0.94	65.76	514.90	14.75	11.6
Foot	2.23	64.47	500.15		
Hunters Rapids:					
Head	3.79	62.91	498.28	4.27	3.1
Foot	4.26	62.44	494.11		
Tucannon Creek, mouth	4.74	61.96	492.80	.....	.....
Palouse Rapid, head	5.20	61.50	492.19	15.13	6.8
Head of chute	6.40	60.30	482.30		
Palouse Rapid, foot	7.40	59.30	477.06		
Rapid No. 4:					
Head	7.61	59.09	476.97	1.16	4.4
Foot	7.86	58.84	475.81		
Palouse River, mouth	7.63	59.07	476.97	.....	.....
Lyons Ferry	8.09	58.61	475.60	.....	.....
Riffle No. 5:					
Head	8.53	58.17	475.40	5.11	1.6
Foot	9.20	57.50	470.29		
Skiff Bar Rapids:					
Head	12.50	54.20	468.21	10.14	7.6
Foot	13.87	52.83	458.07		
Masculine Bar	15.36	51.34	456.70	.....	.....
False Palouse Rapid:					
Head	15.75	50.95	456.16	2.05	4.7
Foot	16.18	50.52	454.11		
Riffle No. 8:					
Head	17.18	49.52	453.49	4.16	3.2
Foot	17.68	49.02	449.33		
Rapid No. 9 (Gores Dread):					
Head	20.15	46.55	446.02	1.92	5.6
Foot	20.50	46.20	444.10		
Monumental Rapid:					
Head	22.25	44.45	441.80	2.19	16.6
Foot	22.38	44.32	439.61		
Shoal below Monumental	23.40	43.30	437.32	.....	.....
Old Washtucna Ferry	24.60	42.10	.....	.....	.....
Rapid No. 11:					
Head	24.57	42.13	436.00	8.99	7.1
Foot	25.83	40.87	427.01		
Rapid No. 12 (Pine Tree Rapids):					
Head	30.28	36.42	422.33	8.36	7.9
Foot	31.38	35.32	413.97		
Rescue Island, head	32.25	34.45	413.74	10.06	6.0
Rapid No. 13, head					
Long Crossing Bar, head	33.20	33.50	408.89		
Rescue Island, foot					
Long Crossing Bar, foot	33.80	32.90	403.68		
Rapid No. 13, foot					
Minnie Coats Island, head	34.92	31.78	403.17	3.68	5.8
Rapid No. 14, head					
Rapid No. 14, foot	35.60	31.10	399.51	.....	.....
Minnie Coats Island, foot	36.00	30.70	399.25	.....	.....
Walkers Landing	36.73	29.97	398.49	.....	.....
Fords Landing	37.90	28.80	396.12	.....	.....
Shoal below Fords Island	38.20	28.50	394.60	.....	.....
Rapid No. 15:					
Head	38.88	27.82	389.89	2.30	4.6
Foot	39.38	27.32	387.59		
Copelys Cut-off:					
Head	42.52	24.18	384.97	5.91	6.6
Foot	43.44	23.26	379.06		
Shoal above Anchor Canyon:					
Head	44.55	22.15	378.07	5.08	4.8
Foot	45.35	21.35	372.99		
Anchor Canyon:					
Head	45.40	21.30	373.10	.....	.....
Foot	47.00	19.70	373.04	.....	.....
Fish Hook Ferry	47.20	19.50	372.94	.....	.....
Fish Hook Rapids:					
Head	48.90	17.80	370.73	11.30	7.1
Foot	50.26	16.44	359.43		
Three Island Bend, head	52.55	14.15	357.60	.....	.....
Riffle No. 19, head	53.50	13.20	353.40	2.60	5.2
Three Island Bend, foot					
Riffle No. 19, foot	53.88	12.82	350.40		

Tabulated list of rapids, shoals, and prominent points—Continued.

Locality.	Distance from Riparia.	Distance from mouth of river.	Elevation of water surface.	Fall of water.	Rate of fall per mile.
20:					
	54.40	12.30	350.10	.74	9.25
	54.48	12.22	349.36		
t Point	55.45	11.25	347.31		
and:					
	55.80	10.90	346.86	3.91	5.92
	56.46	10.24	342.95		
Rapid:					
	60.62	6.08	336.70	4.33	9.84
	61.06	5.64	332.37		
22:					
	61.85	4.85	329.60	1.79	8.95
	62.05	4.65	327.81		
23 (Perines Defeat):					
	63.00	3.70	325.25	3.20	8.00
	63.40	3.30	322.05		
Bar	64.60	2.10	320.59		
Bridge	65.30	1.40	319.25		
24:					
	66.40	.30	317.39	2.30	16.47
	66.57	.13	315.09		
river	66.70		314.44		

TION OF RAPIDS, SHOALS, LANDINGS, AND PROMINENT POINTS ON SNAKE RIVER, WASHINGTON, BETWEEN RIPARIA AND THE MOUTH.

aria.—A station on the main line of the Oregon Railway and Navigation y's railroad, which crosses the river at this point. Riparia is on the left bank. opposite is Texas City. The population of both is about 50 souls. Riparia wer terminus of the steamboat line to Lewiston. All freight to or from points is transferred here. The river is crossed by a steel bridge of three ith masonry piers founded on bed rock. The drawspan on the left side of has a clear span of 157.6 feet.

s Rapid (1 mile below Riparia).—This rapid is 1.3 miles long and has a fall feet, or at an average rate of 11.43 feet per mile. The river is here 1,750 e between high-water lines and 1,500 feet wide between low-water lines, t of this width being taken up on the right-hand side by shoals and bowlders. nel follows the left bank at an average distance of 300 feet. This obstruc- lts from an insufficient section, especially during low stages. The channel rough extensive rock reefs of irregular formation, a great deal of which is le submerged and obstructs and narrows the channel, producing by its g effects currents of from 9½ to 12 miles an hour. The object of the improve- re should be directed to straightening the channel and enlarging the cross so as to reduce the damming effect of the present contracted portion of the

The work should mainly be directed to that portion of the bed of the ween 1,350 and 2,200 feet below the head of the rapid. It is estimated that val of 12,640 cubic yards of rock is necessary to afford a clear channel, free nage to passing steamboats at extreme low water. Of the above amount bic yards are above water, 11,500 cubic yards submerged. The work on this very difficult and dangerous, owing to the extremely swift water, and can prosecuted at favorable stages, near low water. The estimated cost of this sed on work previously carried on on the Snake, briefly stated, is as follows:

bic yards, at $2	$2,280.00
bic yards, at $5	57,500.00
tal	59,780.00

ork heretofore done on the rapid is as follows:

). 692.66 cubic yards, at $18	$12,467.88
3. 490 cubic yards	4,693.77
Office and superintendence	851.57
3. 1,355 cubic yards, at $4.19	5,577.45
bic yards, 2,537.66	23,590.67

3. *Hunters Rapid* (3.8 miles below Riparia).—This is a short rapid, with strong current and fairly rough water. The channel is deep, though slightly crooked, and is obstructed at but one point, where a submerged rock of probably 30 cubic yards should be removed. Estimated cost, 30 cubic yards at $7, $210.

4. *Mouth of Tucannon Creek* which empties into the Snake, on the left, 4.74 miles below Riparia. This stream has a low-water width of about 30 feet, and carries but little water except at flood seasons. The railroad leaves the river at this point and passes up the valley of Tucannon Creek.

5. *Palouse Rapid* (5.2 miles below Riparia).—This rapid has a length of 2.2 miles and a fall of 15.13 feet, or at an average rate of 6.88 feet per mile. The river is 940 feet wide at the head, but at a distance of 1.2 miles below it suddenly narrows to a width of but 120 feet, and from there flows between low rock walls. The channel is deep and carries a strong current, with many strong whirls. Near the lower end the channel has a width of 70 feet and a depth of 100 feet. There are different channels through this rapid at different stages of water. At lowest stage the channel is directly through the center. At 10 feet stage the channel passes to the north side, and at higher stages the channel is on the south side. In each case the course is taken so as to avoid the strongest current. It is believed that this rapid now presents no serious impediment to low-water navigation.

Statement of work done on Palouse Rapid.

1881.	869.11 cubic yards removed, at cost of		$21,727.75
	740.73 cubic yards removed, at cost of		12,222.05
	1,609.84 cubic yards removed, at cost of		33,949.80

6. *Rapid No. 4* (7.61 miles from Riparia).—This rapid is short and presents no obstacle. Length one-fourth of a mile, with fall of 1.16 feet; average rate per mile, 4.64 feet.

7. *Palouse River* (7.63 miles from Riparia).—This stream has a low-water width of about 40 feet and carries but little water. It empties into the Snake from the north.

8. *Lyons Ferry and Berry Post-Office.*—Point where the Mullan wagon road crosses the Snake.

9. *Rapid No. 5* (8.53 miles below Riparia).—This rapid is 0.67 mile in length, and falls in that distance 5.11 feet, or at an average rate of 7.63 feet per mile. The channel has a least depth of 5 feet. Several bowlders, aggregating probably 60 cubic yards, require removal. Estimated cost, 60 cubic yards, at $8 per cubic yard, $480.

10. *Skiff Bar Rapid* (12.50 miles below Riparia).—This rapid is 1.37 miles in length, and falls in that distance 10.14 feet, or at an average rate of 7.4 feet per mile. The fall for first half mile is 6.09 feet, or at an average rate of 12.18 feet per mile. The channel is shoal and slightly crooked, with a least depth of 5 feet. A number of bowlders, amounting probably to 100 cubic yards, should be removed. Estimated cost, 100 cubic yards, at $8, $800.

11. *Masculine Bar* (15.36 miles below Riparia).—A landing from which a yearly shipment of wool is made.

12. *False Palouse Rapid* (15.75 miles below Riparia).—This rapid is 0.43 mile long, with fall of 2.05 feet in that distance. Average rate per mile, 4.77 feet. The channel is straight and narrow, and flanked by submerged rock walls which cause numerous whirls. No improvement necessary. Some work was done on this rapid in 1881, when 8.69 cubic yards were removed, at a cost of $143.39.

13. *Rapid No. 8.*—This is a shoal rapid—least depth 5 feet; 17.18 miles from Riparia. It has a length of one-half mile and a fall of 4.16 feet, or at an average rate per mile of 8.32 feet. The width of the river at the head is 1,280 feet between water lines. It is believed that this rapid will require no work at present. On all the rapids and shoals are annually occurring obstructions in the shape of bowlders transported by ice and high water. These are generally of small size and often do not cause any disturbance of the water by which they may be located, but are still a source of danger to passing steamboats.

14. *Rapid No. 9* (known as Gores Dread, 20.15 miles from Riparia).—This rapid has a length of 0.35 mile and a fall of 1.92 feet, or at an average rate per mile of 5.48 feet. The channel is straight, with irregular bottom, and has a least depth of 6 feet. A number of bowlders, aggregating some 60 cubic yards, should be removed. Sixty cubic yards, at $8 per cubic yard, $480.

15. *Monumental Rapid* (22¼ miles from Riparia).—This rapid has a length of but 0.13 mile and a fall of 2.19 feet, or at an average rate per mile of 16.85 feet. It is formed by a low reef extending diagonally across the channel. The channel skirts this reef on the left-hand side, and finally passes over it near the lower end. The reef is prolonged at its lower end by a long gravel bar to the opposite shore. At a low stage the reef is submerged about 1 foot. The channel is crooked and carries

a very strong current with rough water. There is but 4 feet of water on the reef. The improvement at this point should be directed to reducing the crest of the ledge. This will also lower the water surface at that point and also above the reef where the water is shoal with cobblestone bottom.

Estimated that it will require the removal of 1,200 cubic yards of solid rock and also the removal of a considerable amount of cobblestone by raking.

Estimated cost.

1,200 cubic yards submerged rock, at $5	$6,000
20 days' raking with steamer, at $40 per day	800
Total	6,800

The work previously done at this point is as follows: 1879–80, 137.50 cubic yards, at $18, $2,475.

16. *Shoal below Monumental* (23.4 miles below Riparia).—This shoal has a least depth of water of 6½ feet. The channel is slightly crooked. Several bowlders, amounting to about 20 cubic yards, should be removed. Estimated cost, 20 cubic yards, at $5 per yard, $100.

17. *Old Washtucna Ferry* (24.60 miles from Riparia).—Now abandoned.

18. *Rapid below Washtucna Ferry* (24.57 miles below Riparia).—The river is here 1,520 feet wide between water lines, and is obstructed by a cobblestone island in the center of the river. The channel on the right is obstructed by a bar at the lower end of the island. The steamboat channel closely follows the left shore. The rapid has a length of 1.26 miles, and falls in that distance 8.99 feet, or at an average rate of 7.14 feet per mile. The fall for the first half mile is 5.22 feet, at rate of 10.44 feet per mile. A number of bowlders require removal, probably 50 cubic yards. Estimated cost, 50 cubic yards, at $8, $400.

19. *Pine Tree Rapid* (30.28 miles from Riparia).—This has a length of 1.1 miles and falls in that distance 8.36 feet, or at an average rate of 7 60 feet per mile. This obstruction is formed by two belts or reefs of lava, or basaltic rock, which extend across the river nearly at right angles to the direction of the current and at an average height of 1 foot above extreme low water. The river has a width of 1,250 feet at the head. The first reef is about 400 feet wide. The channel through this has a width of 150 feet. Through this chute the water rushes with great velocity. A minimum depth of 5 feet was found here.

The second belt or reef is about 3,000 feet wide. The channel passes through the center of this reef, skirting a long island of cobblestones on rock foundation, which lies on the left. Through the upper part of the reef the channel is but 90 feet wide, and the water rushes through this chute with great velocity and with many strong whirls, which make it very hard to hold a boat in the channel, the tendency of the whirls and cross currents being to throw the boat against the sharp and jagged points of the flanking reefs. Near the lower end the channel becomes wider but with several obstructions, consisting of submerged reefs and points of rock in position. The channel on the left carries but little water, and falls abruptly at the lower end over a basaltic ledge. The least depth of water found in this channel was 5 feet, except at the lower end, where the channel widens and is obstructed by several points of rock.

The improvement at this obstruction should be directed to widening the section and reducing the slope and current through the second reef. It is estimated that the removal of 8,900 cubic yards would be necessary. This should be removed from either side of the second chute at the head, and from the right side at the bottom; also the submerged obstructions at the lower end of the same chute, in the center and on the left side of the channel.

Estimated cost.

2,670 cubic yards above water, at $3	$8,010
6,230 cubic yards submerged, at $5	31,150
Total cost	39,160

The following work has been done at this point:

1876.	477.51	cubic yards removed, at cost of	$11,818.37
1878.	664.28	cubic yards removed, at cost of	8,635.64
1888.	1,010	cubic yards removed, at cost of	4,231.90
	2,151.79	cubic yards removed, at cost of	24,685.91

20. *Rescue Island Rapid.*—This is a long and slightly crooked rapid beginning at the head of Rescue Island, 32.25 miles below Riparia. Length of rapid, 1.55 miles; fall, 10.06 feet; rate per mile, 6.43 feet. This rapid may be considered in two sections, the first extending from the head to the foot of Rescue Island; the second extending from the foot of Rescue Island, which is also the head of Long Crossing Bar, to the lower end of Long Crossing Bar.

The first section of the rapid is obstructed by two ledges at about the middle of the island. These are about 1 foot above low-water level, and lie in the center of the channel. They amount together to about 150 cubic yards. Estimated cost of removal, 150 yards, at $4 per yard, $600.

Long Crossing Bar is about 4,500 feet in length, and extends from the lower end of Rescue Island diagonally across the river to the left bank. The average depth of water on this bar is 2 feet. The greatest depth found on any crossing is 3 feet, at a point 2,400 feet below the end of the island. The bar is 300 feet wide, and the water falls over it as over a dam. The fall in that distance is 0.88 foot, at an average rate of 14.56 feet per mile.

It is believed that the construction of a dike from the lower end of the island along the upper side of the bar for a distance of 2,000 feet from the island would deepen the water on the crossing so as to give ample depth for steamboats. The dike should extend 400 feet upstream from the lower end of the island, in order to change the direction of the current gradually and to protect the bank from washing out. After the dike is completed it would probably be necessary to remove a considerable amount of cobblestones in the line of the channel across the bar on the upper side, in order to reduce the slope and consequent velocity of the current. The construction of a second dike below the end of the first dike, and running from the left shore to the bar at right angles to the general course of the river, might prove to be necessary, but is not recommended. The average depth of the water along the line of the first dike is 3 feet. A height of 2 feet above low water should be sufficient. Estimated cost of the improvement is as follows:

2,400 linear feet of stone dike, at $4.50 per foot	$10,800
10 days' raking with steamboat, at $40 per day	400
Total	11,200

21. *Couch Island Rapid.*—At upper end of Couch, or Minnie Coats, Island, 34.92 miles from Riparia. This is a short, rough rapid, over a cobblestone bottom, with a crooked channel, lying to the left of Couch Island. It has a length of 0.68 mile and falls in that distance 3.66 feet, or at an average rate of 5.38 feet per mile. The fall for the first one-fourth mile is 2.77 feet, or at a rate of 11.08 feet per mile. The current sets strongly against the left bank. Ascending boats have considerable difficulty in lining up. The right channel carries about 4 feet of water and has light current. It is obstructed by several bowlders which should be removed. This will give a free channel at all stages above 1 foot above low water. At low-water stage the left channel must be taken, where the only difficulty lies in the swiftness of the current. Estimated cost, 80 cubic yards, at $5, $400.

22. *Walkers Landing* (36.73 miles from Riparia).—A former shipping point for grain from Eureka Flat, on left bank.

23. *Fords Landing* (37.9 miles from Riparia).—A former shipping point for grain from Eureka Flat, on left bank. At this point is a large orchard.

24. *Shoal below Fords Island* (38.2 miles from Riparia).—This is formed by a diagonal bar crossing the river from the foot of Fords Island on the right to the left bank. It carries a minimum depth of 5.5 feet and is apparently unobstructed.

25. *Rapid No. 15* (38.88 miles from Riparia).—A shoal rapid one-half mile in length and materially obstructed by bowlders. The fall is 2.3 feet. An average rate of 4.6 feet per mile. It is estimated that 200 cubic yards of bowlders should be removed. Estimated cost, 200 cubic yards, at $6, $1,200.

Amount removed from this rapid in 1884, 31.49 cubic yards, at cost of $597.93.

26. *Copelys Cut-off—Rapid No. 16* (42.52 miles from Riparia).—The river at this point is obstructed by two cobblestone islands, forming three channels; the right and left channel are shoal an unnavigable. The main channel lies between the two islands. The rapid has a length of 0.92 mile, and a fall of 5.91 feet, or at an average rate of 6.42 feet per mile. At the head of rapid and of islands is a gravel bar with a minimum depth of 5.5 feet. At the lower end the rapid is obstructed by several bowlders, which should be removed. At low water boats have to line over the bar at the head. A reduction of 2 feet on crest of bar would probably reduce the slope and resulting current sufficiently to allow boats to pass over without lining. Estimated cost:

80 cubic yards submerged rock, at $6	$480
8 days' raking with steamer, at $40 per day	320
Total	800

At this point 11.19 cubic yards were removed in 1884, at cost of $241.23.

27. *Shoal above Anchor Canyon—Rapid No. 17.* (44.55 miles from Riparia).—This rapid has a length of 0.8 mile and falls in that distance 5.08 feet, or at an average rate per mile of 6.35 feet. The river at this point is about 1 mile wide between high-water lines. The channel passes through the center. On the right is a gravel bar nearly one-half mile wide, covered with willow brush and overflowed at high water. On the left is a large cobblestone island, separated from the left bank by a narrow and shallow channel. This rapid is crooked, but with a fairly good channel, obstructed at several points by submerged bowlders, which should be removed. Least depth of water, 9 feet. Estimated cost of improvement, 25 cubic yards, at $8 per yard, $200.

28. *Anchor Canyon* (45.4 miles from Riparia).—A straight reach of river 1.6 miles in length, with very little current and deep water in narrow channel.

29. *Fish Hook Ferry* (47.2 miles from Riparia; at lower end of Anchor Canyon).

30. *Fish Hook Rapid* (48.8 miles from Riparia).—This rapid is 1.46 miles in length and has a fall in that distance of 11.3 feet, or at an average rate of 7.74 feet per mile. On shorter reaches the rate of fall exceeds this rate, as the principal part of the fall is concentrated at the three reefs. This obstruction is caused by three reefs of basalt, which cross the channel of the river. Through the openings or chutes through these reefs the current has great velocity, with many strong whirls. Through the upper reef the channel is fairly good, except for several reef points which lie on the right of the center of the channel. Between the first and second reefs is a good channel, with deep water and light current, flanked on each side by low rock walls. At and just above the head of the second chute the current sets toward the right bank, spilling over the shoal reef to the right of the channel. This reef runs diagonally upstream. At the lower chute the reef is submerged about 3 feet, the main body of the reef lying on the right of the channel. On the left are several points of rock projecting from the bottom to within about 1½ feet of the surface. The improvement should consist in:

1. Removing rock points at upper chute, about 50 cubic yards, at $6	$300
2. Widening channel at middle chute by removing 2,700 yards on the left of channel, at $5	13,500
3. Removing 1,100 cubic yards on left of channel, between middle and lower reefs, at $4	4,400
4. Removing rock points at lower reef, 200 cubic yards, at $5	1,000
5. Removing several bowlders at lower end of rapids, 30 cubic yards, at $7	210
Total, 4,080 cubic yards	19,410

The purpose of the improvement at the middle chute is to widen the section enough to reduce the slope and average up the fall.

Work previously done on this rapid is as follows:

1878. Removal of	27.45 cubic yards, at cost of	$356.85
1884. Removal of	488.45 cubic yards, at cost of	9,280.55
1888. Removal of	8.32 cubic yards, at cost of	158.08
	524.22 cubic yards, at cost of	9,795.48

31. *Three Island Bend* (52.55 miles from Riparia).—At this place there are three passages separated by two islands. The left passage is divided at its lower end by a third island. The navigable channels are through the right and middle passages. The middle passage is the one used by steamers, except at extreme low water, when its ascent is impracticable by reason of the strong current and one small rock obstruction. In this channel the fall is concentrated over a short distance, inducing the strong current which bars the passage of ascending steamers. There is a minimum depth of 6 feet of water in this channel.

Through the right channel the fall is more uniformly distributed. On the bar at the head of the island 5 feet of water was found. For the remainder of the distance the channel shows a depth of 6 feet, with a number of projecting ledges and bowlders which should be removed. These would probably aggregate 250 cubic yards. The rock in the middle passage should be removed in order to give a free passage for descending steamers. Amount estimated to be 40 cubic yards.

250 cubic yards, at $5	$1,250
40 cubic yards, at $7	280
290 cubic yards	1,530

32. *Rapid No. 19* (53½ miles from Riparia).—This rapid lies in the right channel at Three Island Bend. It has a length of 0.38 mile, with a fall in that distance of 2 feet, or at an average rate of 5.26 feet per mile. The current is moderately strong.

In the middle channel the rapid has a length of 0.41 mile, with fall of 4.94 feet, or at an average rate of 11.97 feet per mile, with very strong current.

33. *Rapid No. 20* (54.4 miles from Riparia).—This is a short, narrow chute through rock reefs, with ample depth of water. No improvement necessary. Length, 0.08 mile; fall, 0.74 foot; average rate per mile, 9.25 feet.

34. *Hard Rock Point* (55.45 miles from Riparia).—A landmark known to all river men.

35. *Gauge Island* (55.8 miles from Riparia).—A cobblestone island two-thirds of a mile long, lying on the left side of the channel. At the upper end of the island is a shoal carrying 7 feet of water.

36. *Five-Mile Rapid* (60.62 miles from Riparia).—This is short and rough, with very strong current. Length, 0.44 mile; fall, 4.33 feet, an average rate of 9.84 feet per mile. This obstruction is formed by a low reef which extends across the river, a distance of 1,700 feet. The channel passes through the center of this reef. On this rapid is the roughest water seen on the river. The depth is ample. Future improvement should be directed to widening the chute in order to reduce the slope and velocity of the current, but no improvement is now considered necessary. The work done by the Government at this point is as follows:

1878.	401.32 cubic yards removed at a cost of	$5,217.16
1883.	22.02 cubic yards removed at a cost of	275.50
	423.34 cubic yards removed at a cost of	5,492.66

37. *Rapid No. 22 and head of Deans Island* (61.85 miles from Riparia).—The river at this point has a width of 1,570 feet, and is divided by a large island, known locally as Deans Island, into two channels. The right channel is shoal and is not navigable at low water. Rapid No. 22 lies in the left channel at the head of the island. It has a length of 0.2 mile and falls in that distance 1.79 feet, or at an average rate of 8.95 feet per mile. This riffle has two channels; the one on the left carries the deeper water, 6 feet being the least depth found. The bottom is rocky and irregular. A number of bowlders and rock points, aggregating probably 140 cubic yards, should be removed. Estimated cost of improvement: 140 cubic yards, at $5 per cubic yard, $700.

The work previously done by the Government at this point consisted in the removal of rock points and bowlders in 1883, amounting to 26.76 cubic yards, at a cost of $309.88.

38. *Rapid No. 23.—Perines Defeat* (63 miles from Riparia).—This rapid has a length of 0.4 mile, and a fall in that distance of 3.2 feet, or at an average rate of 8 feet per mile. There is an open channel with ample depth. The very strong current is the only impediment to navigation. No improvement necessary.

39. *Ainsworth Bar* (64.6 miles from Riparia).—This is a long diagonal bar, extending from the lower end of Deans Island on the right to the left bank, a distance of about 1 mile. A depth of 3 feet of water was found across this bar. The construction of a stone dike 1,400 feet long, from the left bank to the bar, would benefit navigation at this point by deepening the water on the bar. Estimated cost of improvement, 1,400 linear feet of stone dike, at $4.50 per linear foot, $6,300.

40. *Ainsworth Bridge* (65.3 miles from Riparia).—A steel bridge of 7 spans. The channel is close to the right bank. Width of drawspan in clear, 153 feet.

41. *Rapid No. 24* (above mouth of river, 66.4 miles from Riparia).—This rapid has a length of 0.17 mile and a fall of 2.8 feet, or at an average rate of 16.47 feet per mile. This rapid lies in the channel to the left of the bar island at the mouth of the river. Least depth of water found was 4½ feet. There are no apparent obstructions. The channel to the right of the bar island carries about 2 feet of water, with numerous bowlders obstructing the channel. This was formerly the channel, but is now unnavigable.

42. *Mouth of Snake River.*—At junction of main channel with the Columbia, 66.7 miles from Riparia.

APPENDIX U U.

IMPROVEMENT OF LOWER COLUMBIA RIVER, OREGON AND WASHINGTON, OF WILLAMETTE AND YAMHILL RIVERS, OREGON, AND OF COWLITZ RIVER, WASHINGTON.

REPORT OF MAJ. W. L. FISK, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Willamette River, above Portland, and Yamhill River, Oregon.
2. Columbia and Lower Willamette rivers, below Portland, Oreg.
3. Columbia River, Oregon, below Tongue Point.
4. Mouth of Columbia River, Oregon and Washington.
5. Cowlitz River, Washington.
6. Gauging waters of Columbia River, Oregon and Washington.

EXAMINATIONS.

7. Scappoose Bay and Creek, Oregon.
8. Long Tom River, Oregon.
9. Santiam River, Oregon.

SURVEYS.

10. Clatskanie River, Oregon.
11. Willamette River, opposite Salem, Oreg.
12. Tualitin River, Oregon.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., July 29, 1898.

GENERAL: I have the honor to submit herewith annual report on the works of river and harbor improvement in my charge for the fiscal year ending June 30, 1898.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

U U 1.

IMPROVING WILLAMETTE RIVER ABOVE PORTLAND, AND YAMHILL RIVER, OREGON.

Approved project.—The present project is an extension of the project of 1892 (see Annual Report of the Chief of Engineers for 1897, Part I, p. 507), and contemplates the improvement of the Willamette River

from Portland to Eugene (estimated cost, $131,697), and the construction of a lock and dam in the Yamhill River (estimated cost, $69,000). All of the funds have been appropriated.

OPERATIONS FOR THE FISCAL YEAR 1898.

Willamette River.—Operations by the snag boat and crew were carried on during the entire year.

Up to November work was confined to the stretch of river between the mouth of the Yamhill River and Corvallis, and besides removing numerous snags and overhanging trees, dams were constructed at Black Dog Bar, Rices Bar, head of Lamberts Slough, Lamberts Bend, Matheneys and Lincoln bars.

In November and December, the stage of water being favorable for navigation on the extreme upper part of the river, work was confined largely to snagging between Salem and Eugene; 547 snags were removed from the channel.

In January the work of permanent improvement was resumed, operations being confined to that part of the river between Eugene and Davis Chute (about 8 miles). Dams were constructed at Skinners Bar, Davis Chute, Scatteras Bar, and the mouth of the McKenzie River. This work was finished in March, and the snag boat then dropped down to Harrisburg, removing all troublesome snags on the way, and continuing snagging until Corvallis was reached, about May 15. Four hundred and fifty-one snags were removed.

At Matheneys Bar, 57 miles above Portland, and the shoalest place below Corvallis, a dam 700 feet in length was begun the latter part of May and completed in June. Some repairs were also made to the deflecting dike built at the upper end of this shoal in September. There is already an increased depth at this point.

At the close of the fiscal year, the river being practically free of all snags, and with the increased depth over the shoal places as a result of the permanent works, the channel from Portland to Eugene is in far better condition than it ever has been.

All of the dams were located and built with a view to making as nearly as possible permanent improvement of the river, and wherever such works were constructed beneficial results have been obtained.

For the method of constructing the dams and for other interesting details reference is invited to the report herewith of Mr. David B. Ogden, assistant engineer, in immediate charge.

Yamhill River.—Present low-water navigation extends to Dayton (5 miles). This reach was thoroughly snagged in September, and a 4-foot depth opened through the shoal at the mouth, which is formed each year by a deposit from the Willamette River.

A contract was made with Messrs. Normile, Fastabend & McGregor, of Astoria, Oreg., under date of March 11, 1898, for the completion of the lock and dam in the Yamhill River near Lafayette, Oreg., in accordance with the approved plans and specifications. The contract was approved by the Chief of Engineers March 24, 1898, and provides that the whole work shall be completed on or before December 31, 1898.

Some delay was caused in procuring the necessary land and titles thereto, this being finally arranged and the land purchased (2⅓ acres). Active operations commenced in May.

At the close of the year the keeper's dwelling was about two-thirds finished, the excavation at Martins Shoal, below Lafayette, had been completed, and work on the lock proper commenced.

A cofferdam constructed of round piles and sheeting, with an 8-foot clay core, is about three-fourths completed, and it is expected to begin pumping out the lock pit about July 15. The excavation for land wall has been carried on with teams and scrapers and the bank is now cut away to the level of present water surface and will be completed after lock pit is pumped out. A Lancaster dredge has been at work inside the cofferdam and much of the lock pit is down to grade. About 9,000 cubic yards of earth have been removed to date, and it is estimated that an additional 5,000 cubic yards will complete the excavation.

The amount of excavation will more than double the approximate estimate, in that the bank has been found to contain a much greater percentage of sand than was first indicated, and hence it became necessary to greatly flatten the slopes, carrying same much farther back into the bank.

The total amount of the contract, based upon an approximate estimate of quantities at time of receiving bids, was, in round numbers, $60,000, and included the construction of lock, dam, and keeper's dwelling, and the excavation of a 4-foot channel through Martins Shoal, about 1 mile below the lock.

A revised estimate of the quantities on account of increased excavation, figured on the basis of the contract prices, aggregates, in round figures, $65,500, but as the estimated cost was $69,000 this figure is well within the limit.

This work is also in immediate charge of Mr. David B. Ogden, assistant engineer.

Money statement.

July 1, 1897, balance unexpended		$182,546.26
June 30, 1898, amount expended during fiscal year		36,103.66
July 1, 1898, balance unexpended		146,442.60
July 1, 1898, outstanding liabilities	$8,520.31	
July 1, 1898, amount covered by uncompleted contracts	50,912.32	
		59,432.63
July 1, 1898, balance available		87,009.97

Appropriations.

Act of—		Act of—	
March 3, 1871	$16,000	September 19, 1890	$11,000
March 3, 1873	3,000	July 13, 1892 (of which $3,000 was allotted to Yamhill River)	30,000
June 23, 1874	7,500	August 18, 1894 (of which $2,000 was allotted to Yamhill River)	23,000
March 3, 1875	25,000	June 3, 1896 (Willamette and Yamhill rivers)	40,000
August 14, 1876	20,000	June 4, 1897 (Willamette and Yamhill rivers)	160,000
June 18, 1878	20,000		
March 3, 1879	12,000	Total	448,500
June 14, 1880	12,000		
March 3, 1881	15,000		
August 2, 1882	5,000		
July 5, 1884	10,000		
August 5, 1886	10,000		
August 11, 1888	29,000		

Abstract of proposals for constructing lock and dam in Yamhill River, Oregon, opened by Capt. W. L. Fisk, Corps of Engineers, at 12 o'clock m. on February 10, 1898.

No.	Name and address of bidder.	Excavation, earth (6,000 cubic yards), per cubic yard.	Excavation, rock.		Embankment (3,000 cubic yards), per cubic yard.	Piles (13,000 linear feet), per linear foot.	Lumber.		Concrete (7,400 cubic yards), per cubic yard.
			Lock and dam (400 cubic yards), per cubic yard.	Martin shoal (700 cubic yards), per cubic yard.			Lock foundation, etc. (204,000 feet B. M.), per M feet B. M.	Lock gates and sills (18,000 feet B. M.), per M feet B. M.	
					Cents.	*Cents.*			
1	W. L. Prather, jr., Oakland, Cal	$0.50	$1.30	$1.20	28	30	$11.00	$20.00	$6.23
2	Pugh & Gray, Salem, Oreg	.24	2.50	2.95	64	15	11.75	16.90	5.69
3	Smyth, David & Paquet, Portland, Oreg	1.00	1.50	2.50	20	9	12.00	30.00	6.43
4	Normile, Fastabend & McGregor, Astoria, Oreg	.65	1.50	5.75	15	13	12.00	32.00	5.44
5	Oskar Huber, Spokane, Wash	.73	.85	1.68	17½	18½	14.04	26.00	6.18
6	Wakefield & Jacobsen, Portland, Oreg	.90	1.75	3.00	25	20	14.00	30.00	6.50

No.	Name and address of bidder.	Wrought iron (30,000 pounds), per pound.	Cast iron (25,000 pounds), per pound.	Drainpipe (450 linear feet), per linear foot.	Stone (1,100 cubic yards), per cubic yard.	Brush (80 cords), per cord.	Keeper's dwelling, etc., complete.	Total.
		Cents.	*Cents.*					
1	W. L. Prather, jr., Oakland, Cal	4	3½	$1.00	$1.10	$5.00	$2,000.00	$63,861.60
2	Pugh & Gray, Salem, Oreg	5	5	.20	2.60	2.10	1,900.00	60,950.20
3	Smyth, David & Paquet, Portland, Oreg	2½	4	.20	1.00	3.00	1,500.00	65,370.00
4	Normile, Fastabend & McGregor, Astoria, Oreg	4	4	.20	1.25	1.35	2,200.00	59,918.60
5	Oskar Huber, Spokane, Wash	7½	6½	.80	1.92	1.10	1,898.60	66,176.28
6	Wakefield & Jacobsen, Portland, Oreg	5	5	.75	1.00	3.00	2,250.00	69,723.50

Contract awarded to Normile, Fastabend & McGregor, and executed under date of March 11, 1898.

CONTRACT IN FORCE.

The only contract in force on this work was made with Messrs. Normile, Fastabend & McGregor, of Astoria, Oreg., and was approved March 24, 1898. It provides that work should be begun within ten days from time of notification that the necessary land had been secured and completed on or before December 31, 1898. Work on this contract began in May, 1898.

COMMERCIAL STATISTICS.

These rivers are in the collection district of Willamette. The ports of entry are Portland and Astoria, Oreg. The nearest light-house is at the mouth of the Columbia River.

The following statement of traffic on the Willamette River above Portland has been compiled from reports of the various steamers and transportation companies doing business on this part of the river during the year ending December 31, 1897.

	Tons.		Tons.
Grain	13,173	Wool	626
Piles (1,434 linear feet)	22	Merchandise	58,825
Lumber (1,540,572 feet B. M.)	2,310	Sand and gravel	75,000
Logs (7,116,779 feet B. M.)	17,792	Stone	20,163
Cattle and horses	293	Fish	122
Sheep and hogs	155		
Coal	140	Total	186,621

Passengers carried, number, 87,960.

The canal and locks at Oregon City overcoming the falls of the Willamette River are owned and operated by the Portland General Electric Company, and the following is a statement for the year ending December 31, 1898, of the traffic passing through them:

Grain	tons	6,383½	Paper	tons	17,394½
Flour and mill stuff	do	6,893½	Piles	linear feet	24,630
Coal	do	293	Lumber	feet B. M.	1,811,476
Wool	do	1,106¾	Logs	do	7,443,512
General merchandise	do	16,838½	Wood	cords	2,263½
Potatoes	do	2,767	Passengers	number	26,354
Paper stock	do	1,041	Cattle and horses	do	515
Pulp	do	2,249¼	Sheep and pigs	do	2,531

REPORT OF MR. DAVID B. OGDEN, ASSISTANT ENGINEER.

PORTLAND, OREG., *July 1, 1898.*

CAPTAIN: I have the honor to submit the following report of operations on improving Upper Willamette River, Oregon, for the year ending June 30, 1898:

The work on the Upper Willamette has been confined to the stretch of river between Eugene and the mouth of the Yamhill, a distance of 130 miles, and has consisted of dam construction at various shoals and the removal of snags from the channel.

During the early part of the year dams were constructed at Black Dog Bar, Rices Bar, head of Lamberts Slough, Lamberts Bend, Matheneys Bar, and Lincoln Bar. These dams are of piles, brush, stone, and gravel, and aggregate in length about 3,400 feet.

During November and December the stage of water was favorable for navigation on the extreme upper end of the river, and operations at this time were confined largely to snagging between Salem and Eugene, and 547 snags were removed from the channel during the two months.

In January the work of permanent improvement was again resumed in the vicinity of Eugene, and during the first four months of the calendar year dams were constructed at Skinners Bar, Davis Chute, Scatteras Bar, and mouth of Mackenzie River, aggregating a total length of about 3,800 feet. During the latter part of March, April, and first half of May operations were confined almost exclusively to snagging the 33 miles of river between Harrisburg and Corvallis, and 451 snags were removed.

From an examination of the river during the middle of May it was found that Matheneys Bar, 57 miles above Portland, was the shoalest point below Corvallis, there being but 2½ feet on the bar at a 3-foot stage, and boats were already experiencing trouble in crossing. The river here is about 700 feet in width and is divided into two channels by a narrow gravel island at the center, and it was thought advisable to confine the river to one channel; hence, during the month of June a pile, brush, and gravel dam was constructed across the head of the right-hand channel. While at this date the dam has just been completed, already beneficial results are noticeable in an increased depth of a foot or more over the entire shoal.

Repairs are now being made to the deflecting dike built September last at upper end of Matheneys Shoal, and a closing dike about 500 feet long is also under construction at the head of Lamberts Slough.

The general plan of dam in use on the Upper Willamette is shown upon the tracing accompanying this report, and the method of construction is as follows:

Two rows of fir piles are driven to a depth of 12 feet or more on parallel lines 6 feet apart, the piles in each row being 8 feet apart. Crosspieces, generally 2 by 6 inches by 10 feet, are spiked to each pair of piles about 6 inches above surface of water, and upon these are placed, longitudinally with dam and next the piles, poles 4 to 6 inches diameter and 18 feet in length, the crosspieces and poles forming a temporary support for the brush mattress. Brush fascines, 9 to 12 inches diameter and 16 to 20 feet in length, are laid upon the poles at right angles to the line of dike,

usually in from 4 to 6 layers, and crosswise upon these, both inside and outside the rows of piles, are laid several additional layers; then follow from 4 to 6 more layers placed as at first. Uniformly over the mattress thus formed is placed sufficient gravel, in sacks, to thoroughly weight the whole, after which an additional amount of gravel is dumped upon the mattress at its upper or shore end, which causes the cross bracing beneath to break, allowing the end to sink into place and exert a downward pressure on the adjacent braces, which give way in immediate succession, allowing the whole mattress to sink into place in a few minutes' time.

This method of placing the mattress has been adopted from experience, in that it prevents the continual scouring around the head of the mattress during construction. After the sinking of the mattress the space between the rows of piles is filled with fascines laid longitudinally to a height of several feet above low water, and the whole is then thoroughly weighted with sacked and loose gravel and the filling additionally held in place by 6 to 8 inch diameter cross braces spiked to the upper side of each pair of piles. A waling piece 8 by 10 inches in diameter is bolted on the inside of the lower row of piles, the bottom resting on the cross braces. The piles are cut off level with the top of wale.

In deep-water dams or in those where action of currents has to be strongly resisted, rock in pieces from 25 to 150 pounds is used in lieu of sacked gravel for final weighting.

At places where the water is shoal, deflecting dikes are at times constructed of brush and sacked gravel without the use of piles.

Illustrative of the changes that take place on the Upper Willamette from season to season two sketches of the river in the vicinity of Lamberts Bend, 52 miles above Portland, are herewith submitted. These show the condition at the time of survey, May, 1893, and at the present date. As will be seen, the navigable channel at this place has shifted from one side of the river to the other, and where formerly at low water there was a gravel bar 6 to 8 feet in height, there is now from 6 to 8 feet of water. Such changes take place in the channel all along the Upper Willamette, in consequence of which it would seem impracticable to outline any definite plan of improvement for future operations. While the work has been carried on nearly in line with the approved project, it has in some localities been found unnecessary to build the dams therein outlined, in that the river itself has assumed favorable conditions, while at other localities unlooked-for shoals have formed and additional work has been necessary.

The work of snagging is constant and necessary, and a very noticeable lack of snags is seen in the stretch of river below Salem during the present low-water season, because of the effective operations of the snag boat during high-water season on the upper river.

Steamboat captains running on the river report it to be in better condition than ever before, considering the present low stage of water. The river at this time is at a stage of 1.5 feet above extreme low water, and daily trips are being made from Portland to Salem and Corvallis.

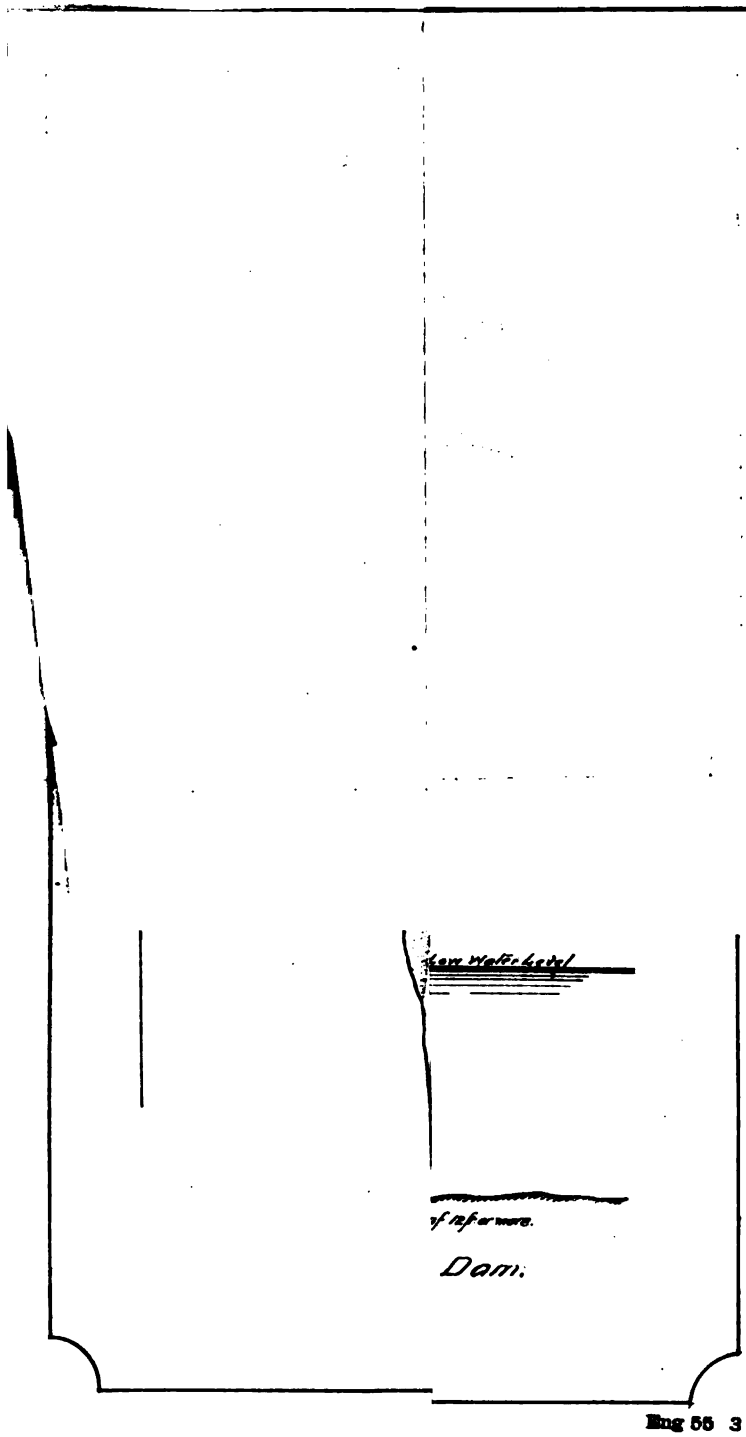
A summary of the work done by the snag boat and plant during the year is as follows:

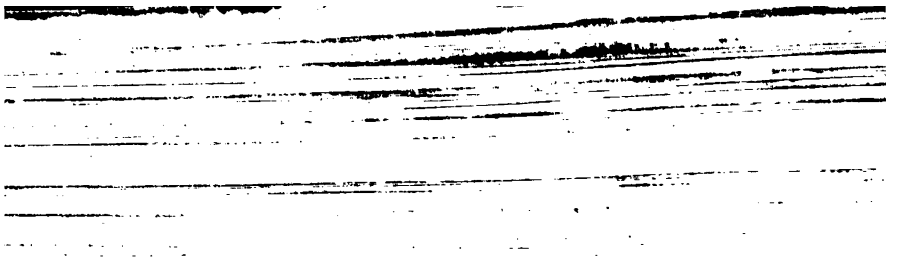
Snags removed	1,269
Miles run	1,678½
Cords wood consumed, including pile-driver supply	465

The average monthly cost of operating snag boat is about $1,150.

Tabulated statement showing the location of dams constructed in the Willamette River during the fiscal year 1893, giving the length, total cost, and the quantities of material and labor used in their construction.

	Black Dog.	Rices.	Matheneys.	Lamberts Bend.	Lamberts Slough No. 1.	Lincoln (2).	Skinners.	Davis Chute.
Length of dam.....feet..	700	500	350	1,100	110	600	1,380	610
Piles.....linear feet..	2,233	1,600	.....	2,600	340	1,600	.....	2,430
Brush.....cords..	398	100	110	552	110	220	.....	1,901
Stringers.....linear feet..	700	375	.....	600	110	375	.....	2,000
Gravel.....sacks..	3,400	425	430	2,150	.....	.....	.....	765
Loose gravel.....tons..	200	150	200	1,350	340	300	.....	2,100
Rock.....do....	.....	50	105	415	140	320	.....	2,650
Iron.....pounds..	200	100	.....	200	40	100	.....	700
Lumber.....feet B. M..	.....	.....	.....	.....	.....	.....	.....	.....
Baling rope.....pounds..	400	100	100	500	80	200	.....	2,000
Labor.....days..	254	128	135	572	143	286	.....	2,000


Low Water Level
of Reservoir.
Dam.



Tabulated statement showing the location of dams constructed in the Willamette River during the fiscal year 1898, etc.—Continued.

	Scatteras.	McKenzies.	Matheneys No. 2.	Matheneys No. 1, repairs.	Lamberts No. 2.	Total.	Cost per unit.	Total cost.
Length of dam.....feet..	925	930	1,023	100	50	8,378	.....	.....
Piles.....linear feet..	.....	.....	4,206	.....	2,800	25,769	$0.04	$1,030.76
Brush.....cords..	.....	.....	600	68	.....	4,059	.....	.....
Stringers.....linear feet..	.....	.....	1,234	.....	.....	6,394	.02½	160.00
Gravel.....sacks..	.....	.....	5,000	.....	.....	12,150	.03½	425.25
Loose gravel.....tons..	.....	.....	500	400	.....	6,540	.....	.....
Rock.....do....	.....	.....	.....	.....	.....	3,089	.93	2,872.77
Iron.....pounds..	.....	.....	250	.....	.....	1,590	.05	79.50
Lumber.....feet B. M..	.....	.....	1,750	.....	.....	1,750	10.00	17.50
Baling rope.....pounds..	.....	.....	900	100	.....	4,350	.08	358.00
Labor.....days..	.....	.....	823	71	49	5,121	1.75	8,961.75
Total cost, 8,378 linear feet dam.....	.....	.....	.....	.....	.....	.....	.....	13,905.53

In the hours of labor given in table the time of the snag boat's crew is not included, and it is fair to assume that one-half should be charged to dam construction, which would make the total cost of 8,378 linear feet of dam $20,850.53, or $2.49 per linear foot.

Respectfully submitted.

DAVID B. OGDEN,
Assistant Engineer.

Capt. W. L. FISK,
Corps of Engineers, U. S. A.

U U 2.

IMPROVEMENT OF COLUMBIA AND LOWER WILLAMETTE RIVERS, BELOW PORTLAND, OREGON.

Approved project.—The project of 1877, providing for a 20-foot channel, was extended in 1891 (Board of Engineers, October 14, 1891) to provide for a low-water channel of 25 feet from Portland to the sea, estimated cost $772,464, and the Port of Portland, a corporation existing under the laws of the State of Oregon, was granted permission to assist in carrying it into execution.

OPERATIONS FOR THE FISCAL YEAR 1898.

The work during the year has consisted entirely of dredging by the hydraulic dredge *W. S. Ladd.* No works of a permanent character were constructed, as the funds available were sufficient only for dredging to maintain the depth already obtained.

The dredge was transferred from the improvement below Tongue Point on August 8, after which work was confined to the general improvement, and during the year 373,089 cubic yards of material were removed from the various bars and shoal places in the Columbia River.

On March 28, the season of high water being close at hand, the dredge was brought to Portland and laid up for extensive repairs.

The Port of Portland operated its bucket dredge during most of the year and removed 185,300 cubic yards of material. Of this amount 53,000 cubic yards were taken from bars in the Willamette River and the balance from Hunters Point Bar, Columbia River. Having purchased the right to use the Bowers patents on the Columbia and Lower

Willamette rivers, the Port of Portland has constructed a 20-inch dredge of that pattern. It was completed and put to work in June. The total cost of this dredge, with 1,000 feet of discharge pipe, was $44,754.

The wheat crop of 1897 was the largest ever harvested in the Northwest, and the season just closed has been remarkable for the large number and size of cargoes passing down the Columbia. Little delay or inconvenience to this fleet was experienced, but the annual freshet, which is now on, will again fill up the shoal places and dredging will be necessary.

In view of the importance of this waterway and the increasing traffic, due to the Alaska trade and the enormous yearly wheat yield, the construction of a dredge of greater capacity is urgently recommended. A new dredge, with the one now in use, working in conjunction with the Port of Portland, will greatly aid in securing and maintaining the proposed 25-foot channel, and the aid to commerce demands that it be built.

The report of Mr. Robert Warrack, assistant engineer, in immediate charge of the work during the year, is herewith, and reference to it is invited for interesting details.

Money statement.

July 1, 1897, balance unexpended	$77,040.71
June 30, 1898, amount expended during fiscal year	22,379.00
July 1, 1898, balance unexpended	54,661.71
July 1, 1898, outstanding liabilities	799.00
July 1, 1898, balance available	53,862.71
Amount (estimated) required for completion of existing project	472,464.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Lower Willamette, act of—		
June 23, 1866	$15,000	
March 2, 1867	50,000	
July 25, 1868 (allotted)	21,000	
April 10, 1869 (allotted)	13,365	
July 11, 1870	31,000	
June 10, 1872	50,000	
		$260,365
Lower Willamette, from Portland to the sea, act of—		
March 3, 1873	20,000	
June 23, 1874	20,000	
March 3, 1875	20,000	
August 14, 1876	20,000	
June 18, 1878	30,000	
March 3, 1879	45,000	
		155,000
Lower Willamette and Columbia, from Portland to the sea, including bar at the mouth of the Columbia, act of—		
June 14, 1880	45,000	
March 3, 1881	45,000	
August 2, 1882	100,000	
		190,000

Columbia and Lower Willamette, below Portland, Oreg., act of—		
July 5, 1884	$100,000	
August 5, 1886	75,000	
August 11, 1888	100,000	
September 19, 1890	100,000	
July 13, 1892	150,000	
August 18, 1894	50,000	
June 3, 1896	100,000	
		$675,000
Total		1,180,365

COMMERCIAL STATISTICS.

This work is in the collection district of Willamette and Oregon. The ports of entry are Portland and Astoria, Oreg. The nearest light-house is at the mouth of the Columbia River.

Arrivals and clearances of vessels at Astoria, Oreg., during the year ending December 31, 1897.

[From collector of customs at Astoria.]

Vessels.	Coastwise.		Foreign ports.		Total.	
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
Arrived	473	357,567	106	172,045	579	529,612
Cleared	410	334,601	116	182,312	526	516,913
Total	883	692,168	222	354,357	1,105	1,046,525

Commerce for the year ending December 31, 1897.

Value of exports	$268,302.00
Value of imports	145,047.00
Duties collected	103,861.75

The exports include 5,107 tons of wheat, 13,475 cases of salmon, and 7,227 tons of lumber.

The principal items of import were 2,837 tons of tin plate and 3,207 tons of coal.

Arrivals and clearances of vessels at Portland, Oreg., during the year ending December 31, 1897.

[From collector of customs at Portland.]

Vessels.	Coastwise.		Foreign ports.		Total.	
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
Arrived	220	288,079	27	42,384	247	330,463
Cleared	153	172,965	96	156,134	249	329,099
Total	373	461,044	123	198,518	496	659,563

Commerce for year ending December 31, 1897.

Value of exports to foreign countries	$7,202,223.00
Value of imports from foreign countries	1,469,531.00
Duties collected	2,268,229.70

Comparative statement of shipments of wheat and flour from Portland for the past ten years.

Year ending—	Wheat.	Flour.	Total.
	Tons.	*Tons.*	Tons.
July 31—			
1888	223,119	64,411	287,530
1889	162,483	65,503	227,986
1890	104,828	52,343	157,171
1891	207,561	63,889	271,450
1892	227,406	52,907	280,313
1893	190,907	57,906	248,813
Dec. 31—			
1896	207,327	56,202	263,529
1894	244,405	45,454	289,859
1895	275,573	65,399	341,972
1896	243,248	77,822	321,070
1897	269,053	65,792	334,845

Statement of principal articles shipped from and received at Portland by deep-sea vessels during the calendar year 1897, coastwise trade not included.

Articles.	Tons.	Articles.	Tons.
SHIPMENTS.		RECEIPTS—continued.	
Flour	43,683	Rice and rice flour	1,997
Wheat	226,943	Hemp, manila, and jute	1,508
Canned salmon	31	Glass	[illegible]
Timber	17,067	Sugar	1,556
Steel rails	984	Soda, soda ash, and caustic soda	416
Wire nails	945	Sulphur	1,157
Raw cotton	759	Tea	436
Total	290,412	Coffee	66
RECEIPTS.		Raw and waste silk	73
Cement	10,217	Tin and tin plate	300
Coal and coke	25,879	Chloride of lime	4
Salt	3,068	Teas	552
		Total	47,345

a Entered at Portland for transportation to other points.

NOTE.—Only a small proportion of the wheat surplus from the harvest of 1896 was carried into 1897, while a large surplus of the harvest of 1897 is being carried over. This will account for the decrease in 1897, and will very materially increase the exports for 1898.

The following statement of traffic on the Columbia and Willamette rivers has been compiled from reports of the various steamers and transportation companies doing business on these rivers during the calendar year 1897. It includes freight carried in coasting vessels to and from Portland, but not that transported in deep-sea sailing vessels.

	Tons.		Tons.
Grain	43,156	Merchandise	242,357
Piles (1,526,565 linear feet)	22,899	Fish	30,039
Lumber (40,595,345 feet B. M.)	60,893	Passengers	21,128
Logs (146,874,674 feet B. M.)	467,187	Shingles	899
Cattle and horses	4,647	Sand and gravel	100,882
Sheep and hogs	78	Stone	501,660
Coal	1,457		
Wool	2,104	Total	1,499,337

Registered tonnage over Columbia River Bar.

INWARD TO ASTORIA AND PORTLAND.

Years.	Deep-sea sailing vessels.						Coasters.		Total.	
	American.		British.		Other flags.					
	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.	Number.	Tonnage.
1890	8	11,568	46	64,028	2	3,038	387	333,690	443	412,324
1891	7	9,954	95	124,837	7	7,826	393	332,374	502	474,991
1892	15	21,834	84	114,485	6	7,699	344	252,170	449	393,188
1893	19	20,585	62	94,108	3	3,528	251	188,107	335	306,328
1894	22	17,239	69	114,102	9	14,478	190	206,005	290	350,816
1895	31	22,678	122	201,042	20	30,115	589	473,433	762	727,268
1896	12	8,816	107	165,850	8	10,850	512	346,302	639	531,638
1897	13	11,093	84	146,453	17	28,033	473	357,567	587	543,145

OUTWARD FROM PORTLAND AND ASTORIA.

1890	9	14,155	51	71,679	2	3,038	384	334,225	446	423,115
1891	7	10,849	73	94,490	6	6,619	381	331,963	467	443,921
1892	12	18,165	99	130,405	6	7,332	351	252,734	468	408,636
1893	17	23,046	64	96,658	5	6,397	225	182,076	311	308,177
1894	25	19,244	68	109,893	9	9,703	144	159,227	246	298,067
1895	31	22,246	122	209,973	14	22,776	546	478,037	713	733,032
1896	20	13,863	103	154,419	12	16,116	484	340,446	619	524,844
1897	12	8,829	86	149,189	14	23,214	410	324,601	522	515,831

SHIPBUILDING.

There has been a marked activity in the construction of river and ocean going craft the past year. The Portland builders have all been busy, and besides making extensive repairs in fitting up old boats, to meet the increased demand, a great many new ones have been built.

Wolff & Zwicker, the principal iron-ship constructors, have built 2 light-ships, practically completed 2 torpedo boats, and now have under construction 1 torpedo-boat destroyer and 1 ocean-going tug.

Other builders have turned out 15 stern-wheel steamers, 2 self-propelling and 1 Bowers dredge, besides 4 ocean-going barges.

The stern-wheel steamers were mostly built for the Alaska trade, and some were shipped in a knocked-down condition. The 2 self-propelling dredges were designed and built for mining operations on the Yukon River.

List of steamers plying on the Upper Willamette, Lower Willamette, and Columbia rivers, Oregon and Washington, during the calendar year 1897.

Name of vessel.	Tons.	Depth.	Name of vessel.	Tons.	Depth.
		Ft. In.			*Ft. In.*
Augusta	40	7 0	El Hurd	26	.....
Albany	401	.....	Elmore	467	.....
Alice A	5	.....	Emily M	9	.....
Annarinne	3	.....	Enterprise	137	3 3
Annie	125	.....	E. L. Dwyer	26	5 9
Astorian	234	2 6	Escort No. 2	72	12 0
Altona	189	2 3	Emma Hayward	456	7 5
Alarm	16	5 0	Eclipse	25	5 2
Bailey Gatzert	444	8 0	Fannie	276	5 0
Braemer	2,316	.....	Felida	3	.....
Brisk	1	.....	George W. Elder	1,224	.....
C. M. Belshaw	8	5 8	George W. Shaver	276	2 4
Canby	49	.....	Gertie	3	.....
Chester	98	.....	Gov. Newell	134	1 6
Columbia	1,746	20 0	Grey Eagle	162	.....
Cygnet	2	.....	Gypsy	154	.....
D. S. Baker	566	5 0	Hassalo	350	6 0
Dalles City	296	7 0	Hattie	2	.....
Edith	37	7 6	Hattie Bell	129	4 5
Edyth	1	.....	Harvest Queen	697	6 0
Electric	20	4 7	Helena	1	.....

List of steamers plying on the Upper Willamette, Lower Willamette, and Columbia rivers, Oregon and Washington, during the calendar year 1897—Continued.

Name of vessel.	Tons.	Depth.	Name of vessel.	Tons.	Depth.
		Ft. In.			Ft. In.
Hustler	129	7 0	Relief	102	.....
Hoo Hoo	16	.....	Pearl	8	.....
Iralda	36	6 0	R. Miler	56	6 [illegible]
Ione	213	2 0	R. P. Elmore	57	.....
Ilwaco	62	6 0	Ramona	298	5 0
Joseph Kellogg	272	2 2	Regulator	334	.....
James B. Stephens	26	5 4	R. R. Thompson	913	10 6
Juneau	81	.....	Ruth	388	.....
Katie Weir	4	.....	Sadie B	33	.....
Kehani	85	4 0	Sakana	3	.....
Louise Vaughn	21	6 0	State of California	1,260	24 6
La Camas	19	4 0	Sea Foam	9	.....
Lurline	338	6 0	Sarah Dixon	278	6 [illegible]
Maggie	58	.....	Salem	240	1 6
Maria	184	3 0	Swift	1	.....
Mascot	199	3 0	Telephone	443	4 6
Milkmaid	1	.....	Tacoma	1,311	11 [illegible]
Modoc	337	5 0	T. J. Potter	589	9 6
Mogul	2,353	.....	Tonquin	17	.....
Naiad	8	.....	Undine	280	3 6
Nerka	2	.....	Vancouver	157	.....
Northwest	301	1 3	Victorian	869	.....
No Wonder	235	.....	Volga	48	.....
Occident	2	6 4	Vulcan	219	4 6
Ocklahama	565	6 0	Water Witch	3	.....
O. K.	47	4 6	W. H. Harrison	52	6 [illegible]
Oregon	1,642	.....	Wm. M. Hoag	431	1 6
Oswego	21	.....	W. S. Mason	252	.....
Queen	54	6 2	Wenona	34	6 [illegible]
Rowena	4	.....	Young America	42	4 [illegible]

REPORT OF MR. ROBERT WARRACK, ASSISTANT ENGINEER.

PORTLAND, OREG., *June 30, 1898.*

CAPTAIN: I have the honor to submit the following report of operations on improving lower Willamette and Columbia rivers for the year ending June 30, 1898:

DREDGING.

The work done has consisted in dredging with the suction dredge *W. S. Ladd* at the various points where navigation was being impeded by shoal water.

The localities improved were:

	Cubic yards.
Mouth of Willamette, 12 miles below Portland	8,879
Martin Island Bar, 34 miles below Portland	82,709
Dobelbower Bar, 44 miles below Portland	87,176
Walker Island Bar, 53 miles below Portland	31,043
Pillar Rock Bar, 85 miles below Portland	91,181
Tongue Point Bar (above) 94 miles below Portland	72,165
Total	373,089

Bar above Tongue Point.—At the beginning of the fiscal year the dredge was at work on "Improving Columbia River below Tongue Point" (q. v.), and was not transferred to the general river improvement till August 8, when operations were begun on the shoal above Tongue Point. Work was continued on this shoal until September 15, by which time 72,103 cubic yards had been removed, increasing the depth to about 20½ feet at low water, the depth on beginning work having been but 19 feet below this plane. The former dredging (1895) at this shoal had left a channel 23 feet in depth, so the decrease in depth had been very considerable. This bar is in the estuary section of the river, and is, on account of the expanse of the adjacent sands and the varying tidal currents, one of the most difficult to permanently improve.

Walker Island Bar.—Work on this bar was begun on September 16, but was temporarily discontinued on the 20th, resumed on October 5, and completed on the 15th of the same month. The total amount of material removed was 31,043 cubic yards, increasing the depth from 19 feet at low water to 22 feet at the same stage.

Mouth of Willamette River.—The bucket dredge of the port of Portland commission, which was being operated at the mouth of the Willamette River, having become disabled, the *Ladd* proceeded to this point and began operations on September 21, as immediate relief was required. The channel along the Coon Island revetment had become extremely narrow through the building downstream of the shoal on the upper side of the mouth of the Willamette, and the work done consisted in cutting off the point of this shoal. The shape of the shoal allowed but one suction to be effective and the eddy current in the mouth of the river prevented any very rapid progress. On the 4th of October, when the commission's dredge was enabled to resume operations, the *Ladd* had removed but 8,879 cubic yards. On leaving the mouth of the Willamette the dredge returned to and completed the work at Walker Island Bar.

Martin Island Bar.—On October 16 the *Ladd* was moved to Martin Island Bar, where trouble was being experienced at the foot of the island. The channel at this point was widened and straightened by removing 82,709 cubic yards from the point of the encroaching shoal. The depth of water on the shoal through which the channel was cut was about 18 feet at low water, and at the close of the work, on December 6, the depth in the area added to the channel was nowhere less than 22 feet at low water.

Pillar Rock Bar.—Work was begun on the upper and lower bars at Pillar Rock on December 7, 1897, and finished on January 21, 1898. During this time there were removed 91,181 cubic yards, leaving a channel 250 feet in width and 22 feet in depth over both upper and lower bars, where but 17 feet at low water could be found before work was begun. Some slight delay was caused while at this point by having to set and fit up new pump parts.

Dobelbower Bar.—This was the last point where dredging was done, and 87,174 cubic yards were removed between January 22 and March 28. A channel 22 feet in depth and 150 feet in width was cut through the bar, where, before beginning work, the greatest depth that could be found was 19 feet at low water. Work at this point was delayed a little through the breaking of a flange on one of the suction pipes and the pulling of some troublesome snags by the *Ladd* abreast of Slaughter's wharf, also in the vicinity of La Du wharf. On the completion of the work at Dobelbower Bar the river had begun to feel the effects of the coming summer freshet, and, as no trouble was being experienced at any point, the *Ladd* proceeded to Portland to be laid up and to receive a general overhauling.

COST OF DREDGING FOR THE YEAR.

The following table shows the cost of operating the dredge for the year, including all expenditures except the above extensive overhauling, which can not properly be charged to this year alone.

Statement, August 8, 1897–March 31, 1898.

Amount of material removed ..... cubic yards ..		373,089
Operating expenses, including current repairs		$13,069.60
Coal:		
135 tons Wallsend, at $5	$675.00	
726.17 tons Wellsend, at $5.25	3,812.40	
		4,487.40
Total cost of operating		17,557.00
Cost per yard for the year ..... cents ..		4.706
Cost per yard for coal ..... do		1.182
Coal consumed per yard ..... pounds ..		5.11
Yards dredged per ton of coal ..... cubic yards ..		433
Number of days dredging		163
Cubic yards per day's dredging		2,289
Number of hours pumping		760¼

The amount of coal consumed per yard is greater than last year and the average number of yards dredged per day considerably less than last year. This is accounted for partly by the nature of the work at the mouth of the Willamette, where less than half the material was excavated in the same length of time as at other points. At Dobelbower Bar the rubber lining of the flexible suctions became detached and through collapsing caused a great deal of additional pumping. This defect was not discovered until the dredge was laid up, the trouble having been attributed to the nature of the material excavated. That the cost of dredging throughout the year has been lower than last year is due to the very small sum expended on repairs during the season.

The following is a statement of the total amount of material excavated by the *Ladd* since her construction in 1883:

Year.	Columbia and Lower Willamette.	Columbia River, Washington.	Columbia River below Tongue Point.	Grand total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1893–94	391,900	----------	----------	391,900
1894–95	423,372	----------	----------	423,372
1895–96	228,951	103,633	----------	332,584
1896–97	366,789	----------	103,231	470,020
1897–98	373,089	----------	59,150	432,239
Total	1,784,101	103,633	162,381	2,050,115

There has been no change in the personnel of the crew of the dredge during the year.

WORK OF PORT OF PORTLAND COMMISSION.

The port of Portland commission has operated its bucket dredge at the following points in the Willamette and Columbia rivers:

	Cubic yards.
Swan Island Bar, Willamette River	35,000
St. Johns Bar, Willamette River	
Post-office Bar, Willamette River	
Mouth of Willamette River	18,000
Hunters Point Bar, Columbia River	132,300
Total	185,300

The 20-inch Bowers dredge has been constructed and was put to work during June, 1898, on Swan Island Bar, the amount of material excavated by it being included in the above estimate.

The sum disbursed by the commission on account of dredging has been (exclusive of cost of new dredge) $14,145.85.

The Bowers dredge cost, for hull, machinery, and 1,000 feet of discharge pipe and floats, $44,754.

The past season has been remarkable for the size and number of the wheat cargoes leaving Portland; also the advent of steamers in the foreign grain trade. The following shows the number of grain and flour cargoes leaving for foreign ports:

	Number.	Tonnage.
Sailing vessels	128	371,45
Steamers	11	50,23
Total	139	421,68

The greatest draft carried has been 24 feet, and the largest cargo that of the steamer *Teen Kai*, namely, 5,516 tons.

The above does not include coastwise shipments to or shipments by regular line to China, in which there has been considerable increase.

At the close of the fiscal year, June 30, 1898, the controlling depth at low water between Portland and the sea was 19 feet, but as this was on the shoal above Tongue Point, where the daily tide averages 7 feet, no trouble beyond a few hours delay is experienced.

The Astoria and Columbia River Railroad, following the south bank of the river and connecting Astoria with Portland, was opened for traffic in the latter part of May, 1898.

Respectfully submitted.

ROBERT WARRACK,
Assistant Engineer.

Capt. W. L. FISK,
Corps of Engineers, U. S. A.

U U 3.

IMPROVEMENT OF COLUMBIA RIVER BELOW TONGUE POINT.

Approved project.—The original and present project (see Annual Report of the Chief of Engineers for 1895, pp. 3605–3608, et seq.) was adopted 1896. The ship *Sylvia de Grasse* was wrecked on a rocky ledge about 1 mile below Tongue Point in 1849, as near as can be determined, and for the removal of the wreck and a portion of the ledge upon which it rests, and for supplemental dredging, the river and harbor act of June, 1896, authorized the expenditure of $50,000 of the balance then on hand to the credit of the mouth of the Columbia River improvement. The estimated cost was $121,550.

OPERATIONS DURING THE FISCAL YEAR 1898.

The dredging in progress at the beginning of the present fiscal year was continued to August 7. Operations were confined to the channel immediately above the Sylvia de Grasse Reef, where the encroaching sands had narrowed the channel, causing considerable inconvenience to vessels in making the turn and avoiding the reef.

At the conclusion of operations 59,150 cubic yards of material had been removed, and, with the amount reported last year, makes a total of 162,381 cubic yards excavated from this shoal. Besides being widened and somewhat straightened, the channel had a least depth of 23 feet, where but 19 feet could be carried on the commencement of work, with not over 15 feet over the portion of sands added to the channel.

It is to be hoped, with the increased volume of water passing through this channel, that the present high water will scour out and improve the river at this place and also have a beneficial effect lower down in front of the city of Astoria. To remove the reef, which the aid to commerce would justify, will require the remainder of the money estimated for it in the project.

Money statement.

July 1, 1897, balance unexpended	$47,218.34
June 30, 1898, amount expended during fiscal year	5,648.64
July 1, 1898, balance unexpended	41,569.70

Amount (estimated) required for completion of existing project	71,550.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	71,550.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

June 3, 1896, from unexpended balance to the credit of improving mouth of Columbia River, Oregon and Washington $50,000

For commercial statistics see Columbia and Lower Willamette river report.

U U 4.

IMPROVEMENT OF THE MOUTH OF COLUMBIA RIVER, OREGON AND WASHINGTON.

Prior to commencing the work of construction in 1885 there were from one to three channels across the bar at the mouth of Columbia River, and these channels varied both in location and in depth, the latter being usually from 19 feet to 21 feet, while the location shifted through nearly 180 degrees from Cape Disappointment to Point Adams.

The project for improvement adopted in 1884 contemplated securing a low-water channel depth of 30 feet across the bar at the mouth of the river by the construction of a jetty to extend from the shore near Fort Stevens across Clatsop Spit in the direction of a point about 3 miles south of Cape Disappointment, the jetty to be built of rubble and random blocks of stone of large size resting upon mattresses of brush. Estimated cost, $3,710,000.

The amount expended to June 30, 1897, was $1,961,259.99, exclusive of the sum of $50,000 authorized by the river and harbor act of June 3, 1896, to be applied below Tongue Point.

The jetty, together with its four groins, was completed in the fall of 1895. At the close of the fiscal year 1897 the channel was in nearly the same position as previously reported (Annual Report of the Chief of Engineers for 1896, p. 3251), but the 30-foot depth at mean lower low water was 2,000 feet in width.

A survey of the bar in progress at the close of the fiscal year was completed a few days later. It shows the channel has moved a little farther to the northward during the year, and the least depth on the bar, 29 feet, at mean lower low water is 1 foot less than last year, but this is not surprising considering the very severe storms of last winter and the consequent large movement of sand from the top of Clatsop Spit, depths on its crest having increased as much as 7 feet in some places, and the increase averaging probably 4 to 5 feet.

The survey, also, coming just as the high water of the Columbia began to fall probably developed the worst possible conditions.

The tracing showing the soundings taken is forwarded herewith.

Money statement.

July 1, 1897, balance unexpended	$14,420.01
June 30, 1898, amount expended during fiscal year	2,015.43
July 1, 1898, balance unexpended	12,404.58
July 1, 1898, outstanding liabilities	564.88
July 1, 1898, balance available	11,839.70

Appropriations.

Act of—		Act of—	
July 5, 1884	$100,000	July 13, 1892	$350,000
August 5, 1886	187,500	August 18, 1894	338,180
August 11, 1888	500,000	Total	2,025,680
February 22, 1890	75,000		
September 19, 1890	475,000		

For commercial statistics see Columbia and Lower Willamette river report.

U U 5.

IMPROVEMENT OF COWLITZ RIVER, WASHINGTON.

[his work was in the charge of Capt. Harry Taylor, Corps of Engineers, until November 30, 1897.]

pproved project.—The original and present project was prepared in 9 and adopted in 1880. It contemplates the removal of sand bars, gs, overhanging trees, and rocks to a point about 50 miles above the ıth. The original estimate was $5,000 for the first year and an enditure thereafter of $2,000 per year for maintenance.

OPERATIONS FOR THE FISCAL YEAR 1898.

nagging operations were carried on by a small crew with rowboat n the beginning of the year up to October, after which time the ds were practically exhausted, and aside from blasting out a few gs no further work was done. One small wing dam was constructed a troublesome place and numerous snags and overhanging trees ıoved; a channel of 2 or 2½ feet was secured to Toledo (40 miles). er operations ceased occurred one of the highest waters known, ich left a bar in the bend 1 mile below Toledo and divided the nnel into three parts. This closed low-water navigation above that nt.

o improve the channel so that boats can ascend to Toledo at all sons will require a permanent work at this place to confine the er to one channel. Some work will be required on two bars farther rnstream, and with a small yearly expenditure for snagging, a depth probably 2 or 2½ feet can be maintained.

he aid to commerce and the benefit to be derived from this improve- ıt will amply justify the expenditure.

Money statement.

r 1, 1897, balance unexpended	$1,311.50
e 30, 1898, amount expended during fiscal year	1,227.44
r 1, 1898, balance unexpended	84.06
mount (estimated) required for completion of existing project	Indefinite.
mount that can be profitably expended in fiscal year ending June 30, 1900	3,000.00

ıbmitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—	
June 14, 1880	$2,000
March 3, 1881	1,000
August 2, 1882	1,000
July 5, 1884	2,000
August 5, 1886	2,000
August 11, 1888	3,000
September 19, 1890	$8,000
July 13, 1892	3,000
August 18, 1894	3,000
June 3, 1896	3,000
Total	28,000

COMMERCIAL STATISTICS.

The following statement of traffic on the Cowlitz River has been compiled from reports of the various steamers and transportation companies doing business on this river during the year ending December 31, 1897:

	Tons.		Tons.
Grain	875	Merchandise	9,920
Lumber (1,678,000 feet B. M.)	839	Shingles	4,800
Cattle and horses	600	Fish	110
Sheep and hogs	13		
Coal	350	Total	17,582
Wool	75		

The number of passengers carried during the year was 14,138.

There were also 413,400 linear feet of piles and 15,546,607 feet B. M. of logs towed from this river, not included in the above statement.

U U 6.

GAUGING WATERS OF COLUMBIA RIVER, OREGON AND WASHINGTON.

The object of this gauging is to obtain data for use in connection with the improvement of the river and to supply information to persons interested in its navigation.

The self-registering gauge was reestablished at Astoria in November, 1888; it has been in operation up to the present time, and in view of its importance as a benefit to commerce its maintenance is considered a worthy object.

The amount expended on this work to June 30, 1897, was $6,201.65.

Money statement.

July 1, 1897, balance unexpended	$798.35
June 30, 1898, amount expended during fiscal year	360.00
July 1, 1898, balance unexpended	438.35
July 1, 1898, outstanding liabilities	84.00
July 1, 1898, balance available	354.35
Amount (estimated) for completion of existing project	1,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	1,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—		Act of—	
August 2, 1882	$500	August 18, 1894	$1,000
July 5, 1884	1,000	June 3, 1896	1,000
August 5, 1886	1,000	Total	7,000
August 11, 1888	2,500		

U U 7.

PRELIMINARY EXAMINATION OF SCAPPOOSE BAY, OREGON, FROM ITS MOUTH TO AND INCLUDING THE LOWER PORTION OF SCAPPOOSE CREEK.

[Printed in House Doc. No. 126, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 2, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated September 28, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, giving the results of a preliminary examination of Scappoose Bay, Oregon, from its mouth to and including the lower portion of Scappoose Creek, made to comply with the provisions of the river and harbor act of June 3, 1896.

In view of the fact that the locality referred to in the act is now open to navigation by light-draft river steamers, Captain Fisk is of opinion that this condition meets the present and prospective demands of its limited commerce, and that its improvement is not a work worthy to be undertaken by the General Government. These views are concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers, and by me.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., September 28, 1897.

GENERAL: I have the honor to submit herewith the following report of preliminary examination of "Scappoose Bay, Oregon, from its mouth to and including the lower portion of Scappoose Creek," made in accordance with river and harbor act of June 3, 1896, and letter of Chief of Engineers dated June 16, 1896:

Scappoose Bay is situated in the northwestern part of the State of Oregon and forms the mouth of one of the lesser tributaries of the Columbia River. It empties into what is known as Willamette Slough, about 1 mile from the Columbia, and is distant from Portland, via Willamette River and Willamette Slough, about 30 miles.

Willamette Slough is a minor waterway, 20 miles in length, which parallels the Columbia River and connects the Willamette River near its mouth with the Columbia at St. Helens. Several steamers trading between Portland and St. Helens navigate Willamette Slough daily and at times run into Scappoose Bay.

Scappoose Bay proper is about 3 miles in length and its main axis is northeast and southwest, practically parallel with that of Willamette Slough. The entrance to the bay is about 300 feet wide between banks

* Not reprinted. Printed in House Doc. No. 126, Fifty-fifth Congress, second session.

and has a channel width of 150 feet, with a minimum depth of 8 feet. A short distance above the entrance the bay widens to about 1,000 feet between banks and maintains this width to within about a mile of its head, from which point it gradually contracts to one-half that width. Scappoose Creek flows into the bay from the south about 2 miles above the entrance, and below the mouth of the creek the bay has a good channel depth of about 8 feet and ample width for navigation. Above this point the channel of the bay becomes narrow and winding and the depth decreases to from 3 to 6 feet. The bottom of the bay throughout is of soft mud.

Scappoose Creek parallels the bay on the southeast and is navigable for a distance of about 2 miles above its mouth, having a general depth of about 6 feet. The channel of the creek follows the west bank, along which landings are easily made, and it is here that large quantities of cord wood are loaded on scows for shipment on the Columbia.

Two small streams, Milton Creek and McNulty Creek, flow into the lower bay from the northwest, and during time of freshet quantities of saw logs and cord wood are driven down these streams and flumed across the mud flats of the bay to within reach of the steamer channel. Landings at the banks on the bay are impracticable on account of the adjacent mud flats.

The mean range of tide in the bay is about 1½ feet. The summer flood, however, obliterates all tidal effects and frequently inundates the country adjacent to the bay on the east and south, it being mostly low land as far as the Willamette Slough.

The country to the west of the bay is an upland bench several miles in width, beyond which is higher broken land well covered with excellent growth of fir timber.

The major portion of the lands in the vicinity of the bay and creek is under cultivation and used largely for dairying and cattle raising.

The timber and cord wood production from the highlands to the west is quite extensive and during the period of high water, each season, advantage is taken to remove on barges quantities of cord wood which have been accumulated on the banks during time of low water.

In view of the fact that Scappoose Bay, from its mouth to and including the lower portion of Scappoose Creek, is now open to navigation by light-draft river steamers, it is thought that this condition meets the present and prospective demands of its limited commerce. It is, therefore, not recommended as worthy of improvement by the General Government.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE,
PACIFIC DIVISION,
San Francisco, Cal., October 5, 1897.

Respectfully forwarded.
I concur in the views and recommendations of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

U U 8.

PRELIMINARY EXAMINATION OF LONG TOM RIVER, OREGON, FROM MOUTH TO TOWN OF MONROE.

[Printed in House Doc. No. 127, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 6, 1897.

SIR: I have the honor to submit the accompanying copy of report, dated September 29, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, giving the results of a preliminary examination of Long Tom River, Oregon, from mouth to town of Monroe, made to comply with the provisions of the river and harbor act of June 3, 1896.

Because of the many shoals between Monroe and the Willamette River, Captain Fisk is of the opinion that this stretch of the river is not susceptible of improvement for navigation during the low-water season, though it is thought that sufficient depth might be obtained during the winter season to accommodate the light-draft steamers of the Upper Willamette. The principal obstructions to high-water navigation below Monroe are overhanging trees, together with numerous snags and an occasional brush-covered shoal, and, in view of the comparatively small expenditure that would be required to remove these obstructions in order to afford an opportunity for shipping grain and other products during the high-water season, it is the opinion of the local officer, concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers, and by me, that the locality in question is worthy of improvement by the General Government to the extent named.

An estimate for the work referred to can be prepared without further survey.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., September 29, 1897.

GENERAL: I have the honor to submit herewith the following report of preliminary examination of the "Long Tom River, Oregon, from mouth to town of Monroe," made in accordance with the river and harbor act of June 3, 1896, and letter of Chief of Engineers dated June 16, 1896.

The Long Tom River is tributary to the Willamette, 80 miles south of Portland by direct line and 122 miles distant by river. It rises on the eastern slope of the Coast Range and has a general course south, east, and then north for a distance of 52 miles to the Willamette.

The river, with its tributaries, drains an area of about 430 square miles.

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*Not reprinted. Printed in House Doc. No. 127, Fifty-fifth Congress, second session.

The cultivated portion of the country to the west of the river is about 5 miles in width, and to the east from 2 to 6 miles, extending to the Willamette River.

The natural products of the valley are wheat, hops, fruit, wool, live stock, and all kinds of small farm products, and the mountain slopes to the south and west are well covered with an excellent growth of fir timber. Scattered through this section are about a dozen sawmills of small capacity, which supply the valley and adjacent country with lumber.

The present outlet for the produce of the valley is by wagon road to points on the Willamette River, or to the towns of Eugene, Junction City, or Corvallis, on the lines of the Southern Pacific Railroad, and necessitates freighting a distance of from 5 to 25 miles, which during the winter months is almost impracticable on account of the bad condition of the roads.

The Upper Alsea Valley, adjacent to that of the Long Tom on the northwest, also finds an outlet for limited quantities of grain and other farm produce through this valley by means of wagon road over the mountains.

The town of Monroe is situated on the left bank of the Long Tom, about 10 miles above its mouth, and is the manufacturing center and principal point of shipment for the valley. It supports two 75-barrel flouring mills, one of which is operated by water power from the river and the other by steam power.

The Long Tom River from Monroe to its mouth is extremely tortuous, and the channel at low water varies in width from 25 feet to 300 feet. The bed of the river is formed largely of gravel, and throughout the entire stretch the low-water channel is composed of shallow riffles in groups and intervening pools of slack water, the depth over the same ranging from 6 inches to 10 feet.

Though the banks above the low-water plane are rather bluff, at times of freshet the river is frequently filled bank full, and much of the flood water then finds an outlet to the Willamette through channels in the low divide between the two rivers, overflowing the intermediate country and cutting off communication by road with the points on the railway and Willamette River.

It is at such seasons that a navigable river to Monroe would prove a great benefit to this section.

During the summer months, and frequently until November, the river remains at a low-water stage, with scarcely a depth of 6 inches on the riffles, but immediately after the winter rains set in it begins to rise, until in January a depth of at least 6 feet is usually reached, which depth is maintained until April or May. During the spring of 1896 the steamer *Gipsey* made a trip to Rickards warehouse, 3 miles above the mouth, and took out about 1,000 bushels of wheat. This is the only shipment of grain by steamer made on the river for several years.

Because of the many shoals between Monroe and the Willamette, this stretch of river is believed to be unsusceptible to improvement for navigation during the low-water season, though it is thought that sufficient depth might be obtained during the winter season to accommodate the light draft steamers of the Upper Willamette.

The banks are covered with overhanging trees, which on account of the narrowness of the channel make the river almost impassable at certain points. These trees, together with numerous snags and an occasional brush-covered shoal, form the principal obstructions to high-water navigation below Monroe. * * *

The opportunity of shipping grain and other produce from Monroe during the high-water season would undoubtedly prove beneficial to the Long Tom and adjacent valleys, and in view of the comparatively small expenditure required to accomplish this, the stretch of river between Monroe and the Willamette River is recommended as worthy of improvement by the General Government to the extent named.

Herewith is submitted a sketch showing location of the Long Tom River with relation to adjacent country.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

(First indorsement.)

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., October 5, 1897.

Respectfully forwarded.

I concur in the views and recommendations of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

U U 9.

PRELIMINARY EXAMINATION OF THE SANTIAM RIVER, OREGON, FROM JEFFERSON TO WILLAMETTE RIVER.

[Printed in House Doc. No. 109, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 1, 1897.

SIR: I have the honor to submit the accompanying report, dated October 4, 1897, by Capt. W. L. Fisk, Corps of Engineers, giving the results of a preliminary examination of the Santiam River, Oregon, from Jefferson to Willamette River, made to comply with the provisions of the river and harbor act of June 3, 1896.

It appears from this report that the river, though navigable in its natural state for several months in the year, is practically unused, but one steamboat trip having been known to have been made on the river in several years. The limited commerce of the section is carried by the railroads, and there is consequently not sufficient inducement offered steamers to warrant running the river at any time.

For these reasons Captain Fisk is of the opinion, concurred in by the division engineer and myself, that the river is not worthy of improvement by the General Government.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., October 4, 1897.

GENERAL: I have the honor to submit herewith the following report of preliminary examination of the "Santiam River, Oregon, from Jefferson to Willamette River," made in accordance with river and harbor act of June 3, 1896, and letter of Chief of Engineers dated June 16, 1896:

The Santiam River is situated in the western part of the State, and is tributary to the Willamette about 95 miles above the city of Portland. The Santiam proper is only 12 miles in length, being formed by the junction of two forks named, respectively, North Fork and South Fork of Santiam River. These forks rise on the western slope of the Cascade Range, about 25 miles apart, and are each about 60 miles in length.

The Santiam and its tributaries flow through a rich agricultural district, the main staple production of which is wheat, though other crops are also raised to some extent, and the cattle, sheep, and dairying interests are quite extensive.

This country is traversed from north to south by two branch lines of the Southern Pacific system, and from east to west by the Oregon Central and Eastern Railway.

The town of Jefferson, at the upstream limit of this examination, is located about 3 miles below the junction of the forks, or 9 miles from the Willamette, and is on the main line of the Southern Pacific Railroad.

Two bridges without draws span the river at this point, making Jefferson the present head of navigation for steamers.

The town has a population of about 500, and supports a gristmill of 100 barrels daily capacity, 2 grain warehouses, accessible by rail or river, 2 hotels, 1 hardware store, and 3 general merchandise stores.

In the stretch of river between Jefferson and the mouth there are 7 well-defined shoals and 16 riffles, the depth over which at time of low water varies from 8 inches to 2 feet. The general low water width of the river is from 200 feet to 400 feet, except on the riffles, and the average fall is estimated at about 3 feet to the mile.

The low-water stage of the river usually prevails from July to October, after which time the fall rains begin raising the river rapidly until in December a 6-foot stage is reached, and this elevation is generally maintained with minor fluctuations during the winter and spring months.

At such times the Willamette is also at a high-water stage, and steamers which navigate it may, with little trouble, ascend the Santiam as far as Jefferson.

Snags and overhanging trees, which encroach somewhat upon the channel width, together with several abrupt bends, constitute the only hindrances to high-water navigation, and while these at times call for careful pilotage, they do not present impassable obstructions. Two years ago, at time of high water, the steamer *Grey Eagle* made one trip to Jefferson, taking out a load of freight, and this is the only trip known to have been made on the river for a number of years. Before railroad lines traversed this section the then limited commerce was carried by occasional steamers during the high-water stage, but under the present conditions there does not appear sufficient inducement offered steamers to warrant running the river at any time.

The annual shipment of grain by rail from Jefferson is estimated at 100,000 bushels and about an equivalent amount ground into flour.

In view of the fact that the river, though navigable for several months

of the year, is practically unused, there seems to be no object in attempting to better its high or low water condition, and therefore the Santiam from Jefferson to the Willamette is recommended as unworthy of improvement by the General Government at the present time.

Herewith is submitted a sketch* showing the location of the Santiam River and its tributaries with relation to adjacent country.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., October 6, 1897.

Respectfully forwarded.

I concur in the views and recommendations of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

U U 10.

SURVEY OF CLATSKANIE RIVER TO TOWN OF CLATSKANIE, OREGON.

[Printed in House Doc. No. 218, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, January 10, 1898.

SIR: I have the honor to submit the accompanying report, dated December 20, 1897, with map,† by Capt. W. L. Fisk, Corps of Engineers, giving the results of a survey of Clatskanie River, Oregon, up to the town of Clatskanie, made to comply with the requirements of the river and harbor act of June 3, 1896.

Captain Fisk states that navigation to the town of Clatskanie may be rendered possible at all stages of river and tide by cutting a short channel across the bend immediately below Manzanillo, and another from the bend above this point to the first bend below the town of Clatskanie, and by dredging immediately below the latter point. The cost of this improvement, giving a waterway 6 feet in depth at low water, is estimated at $13,000.

In view of the large amount of commerce on the river and the small sum required to afford the desired relief, it is the opinion of the district officer, concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers, that the Clatskanie River is worthy of improvement by the General Government to the extent indicated.

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

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*Not printed.
†Not reprinted. Printed in House Doc. No. 218, Fifty-fifth Congress, second session.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 20, 1897.

GENERAL: I have the honor to submit the following report on the survey of Clatskanie River, Oregon, to the town of Clatskanie, made in accordance with river and harbor act of June 3, 1896, and the Chief of Engineers' letter dated September 5, 1896:

Clatskanie River is a tributary of the Columbia, which it enters by means of connecting sloughs at a point on the south bank about 65 miles below Portland. The distance from the mouth to the town of Clatskanie is 3 miles and the width of the river about 75 feet, with a depth of about 5 feet at low water, except in the upper portion, where there are shoals over which the depth at low water is from 2 to 3 feet. The river is exceedingly winding and difficult of navigation on this account, and to such an extent during freshets that its passage has been found to be impossible. The river flows through alluvial bottom land with banks about 6 feet above low water and over which the river spreads at high stages.

Clatskanie City, the head of navigation, is a town of about 400 inhabitants and is the distributing point for a large and growing section of country. The principal industries are agriculture, lumbering, and shingle making. The returns for 1896 of the principal company operating on the river show that about 20,000 tons of freight were handled during the year and 22,500,000 feet of logs and piles towed out. In addition to this there are quantities of lumber and logs handled by smaller towing steamers of which no separate return could be obtained.

The draft of steamers navigating this stream varies from 4 to 6 feet.

The average rise of tide at the town of Clatskanie is about 3 feet.

Navigation to the town of Clatskanie may be rendered possible at all stages of river and tide by cutting a short channel across the bend immediately below Manzanillo, and another from the bend above this point to the first bend below the town of Clatskanie, and by dredging immediately below the latter point.

The following is the estimated cost of the above improvements, giving a waterway 6 feet in depth at low water, as shown on the accompanying map:

New channel, 450 feet long, 40 feet wide at bottom, and 6 feet deep at low water, giving a cut 12 feet in depth with side slopes 1½ to 1, 11,600 cubic yards, at 20 cents	$2,320
New channel, 1,500 feet long, same section as above, 38,670 cubic yards, at 20 cents	7,734
Dredging river 1,000 feet long, cut 40 feet wide at bottom, 6 feet below low water, cut being 4 feet deep with side slopes as above, 6,815 cubic yards, at 20 cents	1,363
Removing snags	100
Contingencies, etc	1,483
Total	13,000

In view of large amount of commerce on this river and small sum required to afford the desired relief, the stream is, in my opinion, worthy of improvement by the General Government to the extent indicated, from its mouth to the town of Clatskanie.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., December 27, 1897.

spectfully forwarded to the Chief of Engineers, United States
y.
oncur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

U U 11.

'EY OF WILLAMETTE RIVER OPPOSITE SALEM, OREGON, WITH A
:W OF ASCERTAINING THE NECESSITY OF CONSTRUCTING A REVET-
NT OR DIKE TO MAINTAIN THE CHANNEL AND TO PREVENT THE
TTING OF A NEW CHANNEL THROUGH THE LOWLANDS ON THE
FT BANK.

[Printed in House Doc. No. 120, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, December 2, 1897.

R: I have the honor to submit the accompanying report of October
97, with map,* by Capt. W. L. Fisk, Corps of Engineers, of the
lts of a survey of the Willamette River, immediately opposite the
of Salem, Oreg., with a view of ascertaining the necessity for and
acter and cost of constructing a revetment or dike to maintain the
in its present channel at that point and prevent said river from
ng a new channel through the lowlands on the left bank thereof,
e to comply with requirements of the river and harbor act of June
96.

om a comparison of former maps with the present survey, together
information furnished by those who have lived in the vicinity for
s, it appears that no marked change has taken place in the channel
ntly, and that there is no present indication of change.

the opinion of Captain Fisk, the construction of a revetment or
at this point is unnecessary, and therefore the proposed improve-
t is unworthy of consideration by the General Government at the
ent time. These views are concurred in by the division engineer,
Charles R. Suter, Corps of Engineers.

or the reason that the work is considered to be unworthy of being
rtaken by the United States, no estimate of cost of improvement
bmitted.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

on. R. A. ALGER,
Secretary of War.

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ot reprinted. Printed in House Doc. No. 120, Fifty-fifth Congress, second session.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., October 8, 1897.

GENERAL: I have the honor to submit herewith a report on survey of the "Willamette River, Oregon, immediately opposite the city of Salem," made in accordance with river and harbor act of June 3, 1896, and Chief of Engineers' letter dated September 5, 1896. The terms of the law relating to the survey are as follows:

Willamette River, immediately opposite the city of Salem, with a view of ascertaining the necessity for and character and cost of constructing a revetment or dike to maintain the river in its present channel at that point and prevent said river from cutting a new channel through the lowlands on the left bank thereof.

The Willamette River makes a radical change of course just in front of the city of Salem, deflecting to the left about 50 degrees, and because of the abrupt bend thus made it has been apprehended that a second channel might cut through the lower bank opposite Salem, destroying the county bridge approach and leaving the town inland.

The river and its banks, both above and below Salem, have been carefully examined and surveyed, and the results are submitted herewith upon the accompanying tracing. The average low-water width of this stretch of river is about 800 feet, and the depth varies from 2 to 20 feet.

The bank on the left is mainly clay and sand upon a foundation of gravel, and varies in height from 12 to 20 feet above the plane of low water. On the right, above the city, the bank is a gravel bar from 3 to 5 feet in height above low water, while along the city front the bank is from 20 to 50 feet in height, and is of similar material to that on the left side.

A swale in the left bank, just above the bend of the river, is noted upon the accompanying tracing. This swale was formerly swamp land and became an overflow channel during time of freshet, but of recent years it has been largely filled with deposit of gravel, and at its head a heavy growth of willows and accumulated drift now form an excellent protection.

As the bank at the head of the swale is about 12 feet above the low-water level, the river in rising must first overspread the expansive gravel bar on the opposite side before overflowing at this point, and then the force of the current on the left bank is much reduced and its inclination is to continue along the Salem bank.

Comparison of former maps with the present survey, together with information furnished by those who have lived in the vicinity for years, leads me to believe that no marked change has taken place in the channel of late and that there is no present indication of change.

It is believed that the construction of a "revetment or dike" at this point is unnecessary, and therefore the proposed improvement is recommended as unworthy of consideration by the General Government at the present time.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., October 11, 1897.

Respectfully forwarded to the Chief of Engineers, U. S. A.
I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

U U 12.

SURVEY OF TUALITIN RIVER, OREGON, FROM THE TOWN OF TUALITIN UP TO GASTON, AND OF THE DAIRY FORK UP TO LOUSIGNANT LAKE.

[Printed in House Doc. No. 221, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, January 11, 1898.

SIR: I have the honor to submit the accompanying copy of report, dated December 20, 1897, with map,* by Capt. W. L. Fisk, Corps of Engineers, giving the results of a survey of Tualitin River from the town of Tualitin up to Gaston, and of Dairy Fork to Lousignant Lake, in the State of Oregon, made to comply with the requirements of the river and harbor act of June 3, 1896.

Captain Fisk states that any improvement of either stream would necessarily entail the straightening of its course, and, thus increasing the low-water slope, would decrease the depth, already small, on the various shoals. The clearing out of the river would also produce the same result and cause further decrease. The construction of locks and dams would therefore be necessary before navigation of the upper portions could be carried on.

The estimated cost of the work, which it appears necessary to carry out to secure convenient navigation, is $407,000, and it is the opinion of Captain Fisk, concurred in by the division engineer, Col. Chas. R. Suter, Corps of Engineers, that the interests involved would not justify so great an expenditure.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. W. L. FISK, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 20, 1897.

GENERAL: I have the honor to submit the following report on the survey of Tualitin River, Oregon, from the town of Tualitin, at the crossing of the narrow-gauge railroad, up to the crossing of the Oregon

*Not reprinted. Printed in House Doc. No. 221, Fifty-fifth Congress, second session.

and California Railroad, at Gaston, and up Dairy Fork of said river from its junction therewith, near Hillsboro, to Lousignant Lake, in accordance with river and harbor act of June 3, 1896, and letter of Chief of Engineers, dated September 5, 1896.

The Tualitin River rises in the Coast Range and flows into the Willamette River about 2 miles above Oregon City. The portion surveyed, from Gaston to Tualitin, has a length of about 57 miles, the width varying from 40 feet at Gaston to 160 feet at Tualitin. The banks vary in height from 10 feet to 25 feet at these points. The total fall in this distance is about 60 feet. The greater fall occurs in the first 23 miles, in the upper portion of which it averages 2.7 feet per mile. In the lower portion the depth and slope are affected by a dam constructed by the Oregon Iron and Steel Company at a point a short distance below Tualitin.

The present obstructions to low-water navigation are the extreme crookedness of the river, numerous rapids and shoals over which the thread of the stream wanders from bank to bank (a continuous succession in the upper portion), of submerged logs, and the frequent occurrence of log and drift jams varying from 200 feet to over 1 mile in length. The extreme narrowness of the channel would also render navigation impossible, and it does not appear that the flow is sufficient to maintain a channel of navigable size. At Dilley, 5 miles below Gaston, the upper limit of the survey, a dam has been placed across the river to provide a water power for operating the flouring mill at that point. The fall from the crest of the dam to the water surface below is 9.3 feet at low water.

Dairy Fork enters on the north bank of the main stream, near Hillsboro. The portion surveyed extends back for a distance of about 13 miles to the so-called Lousignant Lake, a dry plain at the time the survey was made. This fork is about 40 feet wide where it joins the Tualitin, and but 12 feet wide where it leaves Lousignant Lake. The banks are from 15 feet to 25 feet in height throughout, and the total fall is about 50 feet, or an average of 4 feet per mile.

The river is surrounded by railroads, and unless that portion of the river from Tualitin to the Willamette were opened by the construction of locks and dams the river would merely act as another route to the railroad at Tualitin, or by portage from this point the freight could be reshipped on the Willamette River. There are numerous county roads throughout the district and to a majority of producers the railroads afford nearer points of shipment than the river. It may be noted in this connection that were the river navigable the distance to Portland from points on it, shipping by river, would be from two to three times greater than to ship by either rail or wagon road, and the time consumed per mile in transit far greater by the river route.

The river has formerly been cleared of drift by private enterprise, and steam navigation carried on, when the stage of the river permitted, for a few years previous to the construction of the railroad on the south bank, but without success.

Small towing steamers are at present operated handling logs on the lower portion of the river where slack-water navigation is afforded by the dam below Tualitin.

The only advantage that it is believed would accrue to the surrounding country through the clearing out of the river would be the more efficient drainage and consequent reduction in the height and duration of floods which, under present conditions, cover large areas of farm land adjoining the river.

Any improvement of either stream would necessarily entail the straightening of its present course, and thus increasing the low-water slope, decrease the depth, already small, on the various shoals. The clearing out of the river would also produce the same result and cause further decrease. The construction of locks and dams would therefore be necessary before navigation of the upper portions could be carried on.

Taking into account the great expense of any improvement and the large annual expenditure that would be necessary to keep the stream open, as compared with any possible reduction in freight rates, I am of opinion that the stream is not worthy of improvement by the General Government.

A tracing* of the survey, showing the river and a profile along the center of its channel, is submitted herewith.

Very respectfully, your obedient servant,

W. L. FISK,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

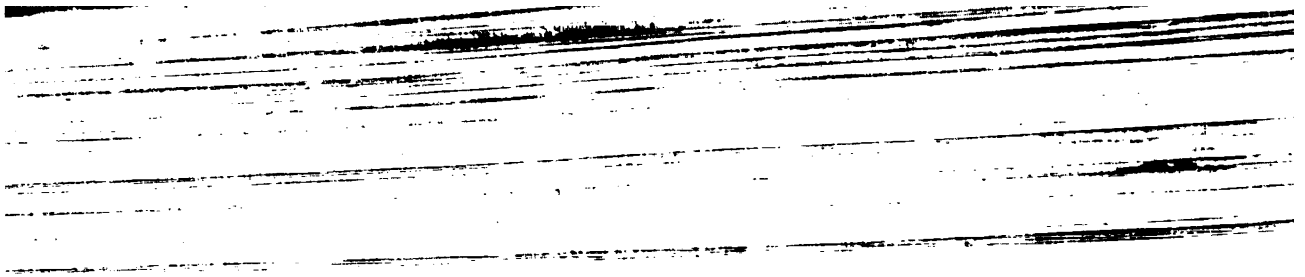
U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., December 27, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

* Only the small index map printed.



APPENDIX V V.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS IN WASHINGTON, IDAHO, AND MONTANA.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1898, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Willapa River and Harbor, Washington.
2. Grays Harbor and Bar entrance, Washington.
3. Chehalis River, Washington.
4. Puget Sound and its tributary waters, Washington.
5. Olympia Harbor, Washington.
6. Waterway connecting Puget Sound with Lakes Union and Washington.
7. Everett Harbor, Washington.
8. Swinomish Slough, Washington.
9. Kootenai River, Idaho, between Bonners Ferry and the international boundary line.
10. Kootenai River above Jennings, Montana.
11. Flathead River, Montana.

EXAMINATION.

12. Neah Bay, Washington.

SURVEYS.

13. Mouth of Willapa River and Mailboat Slough, Washington.
14. Quillayute River and Harbor, Washington.
15. Deschutes River at entrance in Olympia Harbor, Washington.
16. Puyallup River, Washington.
17. Duwamish River and its tributaries, Washington.
18. Skagit River, Washington.
19. Okanogan River, Washington.
20. Pend Oreille River, Idaho and Washington.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., July 16, 1898.

GENERAL: I have the honor to forward herewith * * * annual reports * * * of the river and harbor works in my charge for the year ending June 30, 1898, as follows:

* * * * * * *

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

V V 1.

IMPROVEMENT OF WILLAPA RIVER AND HARBOR, WASHINGTON.

(For previous history, see page 508, Annual Report of the Chief of Engineers for 1897.)

Plan of improvement.—The plan of improvement adopted consists in building a dike of piles, brush, and stone across the head of Mailboat Slough, in order to concentrate the ebbing and flooding currents into the main channel, and thereby produce as great a scour as possible on the shoals at the head and foot of the slough. Also to dredge a channel 100 feet wide and 8 feet deep at low water through the reef just below Willapa City, and to close Louderback Slough with a pile, brush, and stone dike, with the object of compelling the currents to scour a channel through the bar in the river at its lower end. The estimated cost of the work is $31,350.

The project of August 29, 1894, approved by the Chief of Engineers, also provides for cutting a channel through the log jam of North River, a tributary of Willapa Harbor.

Results obtained during the fiscal year ending June 30, 1898.—The work called for by the project having been completed, no work was done during the year and no additional results were obtained. The improved channel maintained itself and the dikes showed but little settlement.

Recommendations and remarks.—It is believed that the effect of the Mailboat Slough dikes has been about as great as can be expected. Willapa Harbor has a comparatively easy entrance, with a depth of about 21 feet at mean lower low water. The average rise of the tide is 8 feet. The harbor entrance is thus sufficient for the general class of coasting vessels, but, owing to the shoals below South Bend, they can not reach the city, and the commerce of the harbor suffers. In order to make the inner harbor depths correspond with the bar depths a channel 20 feet deep at mean lower low water would have to be dredged through two shoals below South Bend.

The dikes already built will probably need occasional repairs, but the funds already appropriated will be sufficient to maintain them for several years. Some further work may be necessary to keep an open passage through the log jam in the North River, and if the balance of the appropriation, or so much thereof as might be necessary, could be made available for the purpose, the work could be done without further appropriations.

The funds already appropriated being sufficient to complete the project, no recommendation for future appropriations is made, but it is recommended that the balance remaining after completing the Willapa River and Harbor work, or so much thereof as may be necessary, be made available for opening a channel through North River jam.

Future operations.—The dikes will be repaired from time to time as may be necessary.

Money statement.

July 1, 1897, balance unexpended	$3,577.20
June 30, 1898, amount expended during fiscal year	250.00
July 1, 1898, balance unexpended	3,327.20

Appropriations.

Act of—	
July 13, 1892	$18,000
August 18, 1894	13,350
Total	31,350

COMMERCIAL STATISTICS.

Willapa is in the collection district of Puget Sound. The nearest light-house is on Toke Point, at the north side of the entrance.

The following statistics relative to the commerce of Willapa River and Harbor were furnished by Mr. Marion D. Egbert and are for the calendar year 1897:

SHIPPING.

Arrivals and departures of vessels.

	Number.	Maximum draft of water.	Aggregate gross tonnage.
Arrived coastwise:		*Ft. In.*	
Steamers	19	17 0	7,011
Sailing vessels	55	20 6	15,159

Steamers and vessels departing were the same. Two steamers are engaged in local traffic on the bay.

Exports and imports.

	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Cranberries	188	$25,000	.....	.....
Shellfish	2,940	104,440	.....	.....
Fish, fresh	161	8,700	.....	.....
Salmon, canned	32	3,600	.....	.....
Merchandise	.....	.....	218	$14,730
Lumber	34,276	156,693	.....	.....
Total	37,597	298,433	218	14,730

V V 2.

IMPROVEMENT OF GRAYS HARBOR AND BAR ENTRANCE, WASHINGTON.

(For previous history, see page 509, Annual Report of the Chief of Engineers for 1897.)

Plan of improvement.—The proposed plan of improvement is to control, by means of a single jetty extending out to sea from the point on the south side of the harbor throat, a distance of about 3½ miles, the ebbing and flooding waters to a sufficient extent to concentrate and direct upon the bar a much greater portion thereof than would naturally go there. It is expected that a depth across the bar of 24 feet at mean lower low water will be obtained.

The jetty is to be of rubblestone built above high-tide level. The estimated cost of the work is $1,000,000.

A full description of this work with plan is published in the Report of the Chief of Engineers for 1895, pages 3517–3528.

In accordance with the authority granted by the act making the first appropriation for the work a "continuing contract" has been let for the entire work.

Results obtained during the fiscal year ending June 30, 1898.—A contract was made and the work begun. A receiving wharf was built on the harbor side of the point from which the jetty is to project, a trestle about 7,000 feet long constructed across the sand spit from the receiving wharf to the jetty proper, and a large plant prepared for the rapid execution of the work.

Report of operations.—Proposals were first received on July 9, 1897, for the execution of the entire work. On account of the lowest bidders being unable to furnish stone of the required sizes and quality from the places specified, and for other reasons, all bids were rejected and the work readvertised. Proposals were again received December 10, 1897. The proposal of the Hale & Kern Contract Company received on the latter date was accepted and a contract entered into.

The winter months were spent in the necessary preparation for the work, and work in the field did not actually begin until March 10, 1898. Since that time the progress has been as rapid as could be expected. The preliminary work, including the building of a large and commodious receiving wharf, bunk and mess houses, etc., and about 7,000 feet of trestle across the sand spit from the wharf to the jetty proper was nearly completed and the work put in such a shape as to permit of rapid progress in the future. The south tongue of the wharf was completed and all the piles driven and half the caps placed in the north tongue. The grillage for storage purposes was partly finished. The piles in the trestle across the sand spit from the wharf to the jetty proper were driven all the way from the wharf to within 650 feet of the high-water line on the ocean side, the caps and the stringers for one track laid and the rails of one track partly laid.

A survey of the bar was made between June 7 and June 22, 1898.

The amounts of material placed under the contract are as follows: 63,355 linear feet piling, 637,439 feet B. M. lumber, 67.683 tons steel rails, and 28,203 pounds iron.

Recommendations and remarks.—The contractors are making their plans to complete the work in the fall of 1900. To do this they are providing a very large and expensive plant, including seven seagoing barges, with a capacity of 1,500 tons each, and a seagoing tug. The plant at the jetty will be such as to enable them to easily unload a full barge load of rock in eight hours, and the plant at their quarry will be ample to load at a corresponding rate. The other work is expected to progress rapidly enough to keep ahead of the rock work. The aggregate estimated quantity of rock required is 570,000 tons. If the contractors succeed in placing in the jetty an average of 20 barge loads of rock per month for four months this season, and the same amount per month for eight months next season and the season thereafter, they would then finish the contract in the fall of 1900. There seems to be no reason why the work should not be carried on with the plant which has been specially provided at least this fast. This plant will when completed have cost in the neighborhood of $200,000, and with such an expensive plant it can readily be appreciated that every effort will be made to utilize it to its fullest capacity, and if the rock can be put in more rapidly than estimated above, it will be. It must also be remembered that the trestle from which the rock is dumped can not be expected to long withstand the winter storms, and any loss of the trestle is liable to cause vexatious delay in the work, as well as additional cost. It is therefore extremely important for the interests of the United States, as well as for the interests of the contractors, that the work be carried to completion as rapidly as possible.

The amount already appropriated is $370,000. The estimated value of the contract is $769,870. In order that the work may not be delayed from lack of funds, the full amount required for its completion should be available during the fiscal year ending June 30, 1900, and in order to cover the expenses of inspection, etc., as well as the contract work, an appropriation of $500,000 is recommended.

Future operations.—It is expected that the jetty will be extended seaward between 2,000 feet and 3,000 feet during the present season, and 8,000 feet to 10,000 feet additional next summer, and completed the year after that, or by the end of the season of 1900, provided there are funds available.

Money statement.

July 1, 1897, balance unexpended		$368,728.24
June 30, 1898, amount expended during fiscal year		7,674.62
July 1, 1898, balance unexpended		361,053.62
July 1, 1898, outstanding liabilities	$2,000.00	
July 1, 1898, amount covered by uncompleted contracts	766,942.90	
		768,942.90
Amount (estimated) required for completion of existing project		630,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900		500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.		

Appropriations.

Act of June 3, 1896	$20,000
Act of June 4, 1897	350,000
Total	370,000

Abstract of proposals received by Capt. Harry Taylor, Corps of Engineers, in response to advertisement dated November 8, 1897, for construction of a jetty at Grays Harbor, Washington.

[Bids opened December 10, 1897.]

Material.	1. Wakefield & Jacobsen, Portland, Oreg.		2. Philip Buehner, Portland, Oreg.		3. Heldmaier & Neu, Chicago, Ill.		4. Hale & Kern Contract Co., Portland, Oreg.	
	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.
Piles, 310,000 feet	$0.11	$34,100.00	$0.12	$37,200.00	$0.13½	$41,850.00	$0.11	$34,100.00
Lumber:								
2,470,000 feet	11.00	27,170.00	15.00	37,050.00	.....	.....	11.00	27,170.00
2,700,000 feet	.....	.....	.....	.....	15.00	40,500.00	.....	.....
Steel railroad rails:								
590 tons 30-pound	45.00	26,550.00	50.00	29,500.00	.....	.....	40.00	23,600.00
792 tons 40-pound	.....	.....	.....	.....	37.40	29,620.80	.....	.....
Iron stirrups and bolts, 100,000 pounds	.03½	3,500.00	.06	6,000.00	.04	4,000.00	.04	4,000.00
Brush, 45,000 cubic yards	.75	33,750.00	.85	38,250.00	.75	33,750.00	1.20	54,000.00
Stone:								
Size A, 125,000 tons	1.16	145,000.00	1.11	138,750.00	.78½	98,125.00	1.10	137,500.00
Size B, 250,000 tons	1.16	290,000.00	1.11	277,500.00	.78½	196,250.00	1.10	275,000.00
Size C, 125,000 tons	1.16	145,000.00	1.11	138,750.00	.78½	98,125.00	1.10	137,500.00
Size D, 70,000 tons	1.16	81,200.00	1.11	77,700.00	.72	50,400.00	1.10	77,000.00
Total	.....	a786,270.00	.....	a780,700.00	.....	b592,620.80	.....	a769,870.00

a Gauge of track, narrow. b Gauge of track, standard.

Contract awarded to the Hale & Kern Contract Company.

Abstract of proposals received by Capt. Harry Taylor, Corps of Engineers, in response to advertisement dated May 10, 1897, for construction of a jetty at Grays Harbor, Washington.

[Bids opened July 9, 1897.]

Material.	The Columbia Construction Co., Portland, Oreg.		Chas. E. Cotton, Oakland, Cal., and Wm. H. Healy, San Francisco.		Huestis, Savage & Scofield, Olympia, Wash.		Buehner & Thorkelsen, Portland, Oreg.	
	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.
Piles, 262,000 linear feet	$0.15	$39,300.00	$0.10	$26,200.00	$0.16½	$43,250.00	$0.12	$31,440.00
Lumber:								
1,870,000 feet B. M. for narrow gauge	16.00	29,920.00	.....	.....	.....	.....	15.00	28,050.00
2,050,000 feet B. M. for standard gauge	.....	.....	11.00	22,550.00	11.50	23,575.00	.....	.....
Steel railroad rails:								
452 tons (30 pounds per yard)	50.00	22,600.00	.....	.....	.....	.....	50.00	22,600.00
608 tons (40 pounds per yard)	.....	.....	32.00	19,456.00	40.00	24,320.00	.....	.....
Iron stirrups and bolts, 83,000 pounds	.05	4,150.00	.03	2,490.00	.03	2,490.00	.06	4,980.00
Brush, 45,000 cubic yards	1.25	56,250.00	1.00	45,000.00	.70	31,500.00	.85	38,250.00
Stone:								
Size A, 125,000 net tons	1.25	156,250.00	1.35	168,750.00	1.53	191,250.00	.98½	123,125.00
Size B, 250,000 net tons	1.25	312,500.00	1.35	337,500.00	1.53	382,500.00	.98½	246,250.00
Size C, 125,000 net tons	1.25	156,250.00	1.35	168,750.00	1.35	168,750.00	.98½	123,125.00
Size D, 70,000 net tons	1.50	105,000.00	.99	69,300.00	1.20	84,000.00	.98½	68,950.00
Total	.....	882,220.00	.....	859,996.00	.....	951,615.00	.....	686,770.00

Material.	Heldmaier & Neu, Chicago, Ill.		C. A. Warren, San Francisco, Cal.		Hale & Kern Contract Co., Portland, Oreg.		I. V. Heaz, jr., Pittsburg, Pa.	
	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.	Bid.	Amount.
Piles, 262,000 linear feet	$0.16	$41,920.00	$0.11	$28,820.00	$0.09	$23,580.00	$0.10	$26,200.00
Lumber:								
1,870,000 feet B. M. for narrow gauge	.....	.....	.....	.....	10.00	18,700.00	.....	.....
2,050,000 feet B. M. for standard gauge	15.00	30,750.00	13.00	26,650.00	.....	.....	10.00	20,500.00
Steel railroad rails:								
452 tons (30 pounds per yard)	.....	.....	.....	.....	30.00	13,560.00	.....	.....
608 tons (40 pounds per yard)	38.50	23,408.00	41.00	24,928.00	.....	.....	47.00	28,576.00
Iron stirrups and bolts, 83,000 pounds	.05	4,150.00	.05	4,150.00	.03	2,490.00	.02⅞	2,407.00
Brush, 45,000 cubic yards	.50	22,500.00	1.40	63,000.00	.80	36,000.00	.70	31,500.00
Stone:								
Size A, 125,000 net tons	.69	86,250.00	1.30	162,500.00	1.10	137,500.00	1.65	206,250.00
Size B, 250,000 net tons	.69	172,500.00	1.30	325,000.00	1.10	275,000.00	1.37	342,500.00
Size C, 125,000 net tons	.69	86,250.00	1.30	162,500.00	1.10	137,500.00	1.30	162,500.00
Size D, 70,000 net tons	.75	52,500.00	1.20	84,000.00	1.10	77,000.00	1.07	74,900.00
Total	.....	520,228.00	.....	881,548.00	.....	721,330.00	.....	895,333.00

All bids rejected.

List of contracts in force during fiscal year 1897–1898.

Name of contractor.	Date of contract.	Date of approval.	Time of commencement.	Time of completion.
Hale & Kern Contract Co	Jan. 26, 1898	Feb. 23, 1898	May 1, 1898	Sept. 30, 1902

COMMERCIAL STATISTICS.

Grays Harbor is in the collection district of Puget Sound. Aberdeen is the subport of entry.

A new light-house has been constructed on the south side of the harbor entrance.

The following information relative to the commerce of Grays Harbor for the calendar year 1897 was furnished by Mr. R. E. Dawdy, of Hoquiam, Wash.:

SHIPPING.

Arrivals and departures of vessels.

	Arrivals.	Departures.
Steamers, coastwise	41	41
Sailing vessels, coastwise	233	216
Foreign	.....	13

Eighty-eight million and twenty thousand feet of lumber were shipped from the harbor during the year, of which 4,238,000 went foreign.

The number of passengers arrived by sea during the year was 124; the number of passengers departing, 84.

The maximum draft of loaded vessels was 17½ feet.

One steamer, draft 13 feet 8 inches, and one schooner, draft 13 feet, were built during the year.

Exports and imports.

Class of goods.	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Basket stock	1,522	$23,000	.....	.....
Lumber and products	145,308	617,003	.....	.....
Machinery and hardware	.....	.....	256	$36,120
Merchandise	.....	.....	3,422	394,024
Stone	.....	.....	400	1,600
Total	146,830	640,003	4,078	431,744

REPORT OF MR. J. M. CLAPP, ASSISTANT ENGINEER.

WESTPORT, WASH., *July 11, 1898.*

CAPTAIN: I have the honor to make the following report of a survey of the entrance to Grays Harbor, made in accordance with your instructions. The field work lasted from June 7 to June 23.

The work done included the topography of the headland known as Damons Point, on the north side of the entrance, as well as that of the south headland, known as Point Hansen.

Natural objects were chosen as signals and others erected for the same purpose, and were used throughout the survey for the location of the position of the survey steamer. These signals were located by triangulation from the extremities of a base measured in an east and west direction a distance of 5,500 feet along the Point Hansen peninsula. The latitude and departure of each was carefully calculated and their position platted on a field map. This map was placed on a drawing board made secure on the house of the survey steamer. The position of the steamer was located every two or three minutes, while working, by position angles, simultaneously measured by two sextants, one angle to the right and the other to the left of a chosen central object or signal, and such position immediately platted on the field map. About 1,500 locations were made and about 7,000 soundings taken.

Extent of survey.—The soundings were made over an area extending from the receiving wharf of the jetty out over the bar sufficiently far to develop the 6-fathom curve. Soundings were made several miles north and south of a line due west from the center of the harbor throat, the lines running from deep water of the ocean toward the shore, toward the spits, or in over the bar, and return.

The bar.—A crescent-shaped one extends from the west end of the south spit toward the north, where it joins the north spit. Between its junction with the south

spit and a point due west from the harbor throat there is a governing depth of about 10 feet at mean lower low water, although a crooked channel of greater depth might be traced.

Toward the north the bar and north spit are particularly lumpy and quite shoal in spots, the 6-foot depth being developed in several places. From the indications of the breaking wave I am inclined to think that shallower depths might be found, but which during the progress of the survey it was quite impracticable to develop.

I was unable to run as many lines of soundings out to the north to more carefully develop the spit on account of the draft of the boat and continued heavy swell. The boat draws 9½ feet of water and, on account of her tonnage, dips heavily into the swell, requiring about 14 feet of water to float her in such places in safety.

No soundings were carried over the spits, either from the steamer or small boats, on account of the breakers, but the steamer approached them from the outside on days when it was most favorable and as closely as was considered safe.

No soundings were carried inside the harbor toward Damons Point, as the channel is too narrow for such a large steamer to be handled.

Canoe Channel.—At its inner end is simply a bay separated from its outlet by a bar or shoal, over which, I should judge, the water flowed to a depth of about 4 feet. Several small channels, separated by low islands of sand bare only at extreme low water, form outlets from what I should call Canoe Bay. The depth of water in these channels is less than in Canoe Channel.

The north spit at extreme low water is made up of three main sand shoals, which are then bare. They are knife-shaped, that is, on their inshore side they have an elevation above extreme low water of perhaps a foot and taper gradually to the water edge. Their shores are more irregular on account of little bays and whirlpool-like holes. The channels are all shallow, with the exception of the one which runs near the shore at Damons Point. This channel is probably 5 or 6 feet deep for its entire length. As much of these islands as could be located instrumentally was done, the rest being drawn in from sketches.

Swash Channel.—Occupies the position where the main ship channel was during the fall of 1894. The south spit, to all appearances, remains practically the same, with the exception that it has moved westward nearly a half mile. At extreme low tide it consists of a triangular island with its apex to the west. It is highest on the channel side and nearer the harbor throat. Like the bar islands on the north spit, it is shaped like a knife blade, its thin edge being toward the sea and its high edge having an elevation of about 1½ feet.

During the time of the survey the weather was not propitious, fog, rain, wind, and heavy swells retarding progress, and consequently increasing the cost of the field work.

A strong littoral current of about 5 miles per hour was running northward.

A bar of less than 18 feet was developed by the soundings between the jetty wharf and the harbor throat.

During the time soundings were made the boat was kept at a uniform rate of about 8 miles per hour.

I respectfully call your attention to a fairly good, though narrow channel from No. 1 buoy, which marks the north spit near the harbor throat a little north of due west, to the sea. This channel is separated from the main harbor entrance by a succession of lumps, which in stormy weather cause the swells to break inside the bar.

Very respectfully, your obedient servant,

J. M. CLAPP,
Assistant Engineer.

Capt. HARRY TAYLOR,
Corps of Engineers.

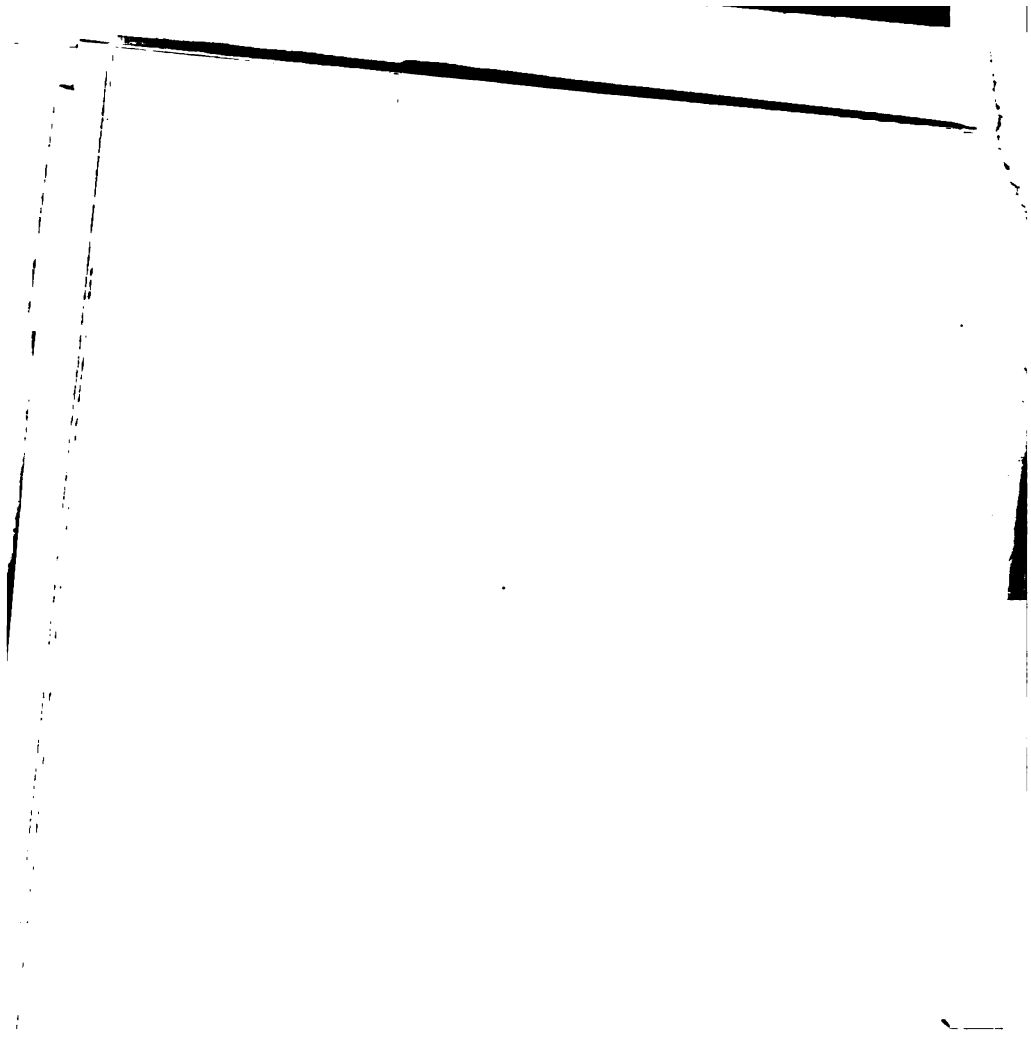
V V 3.

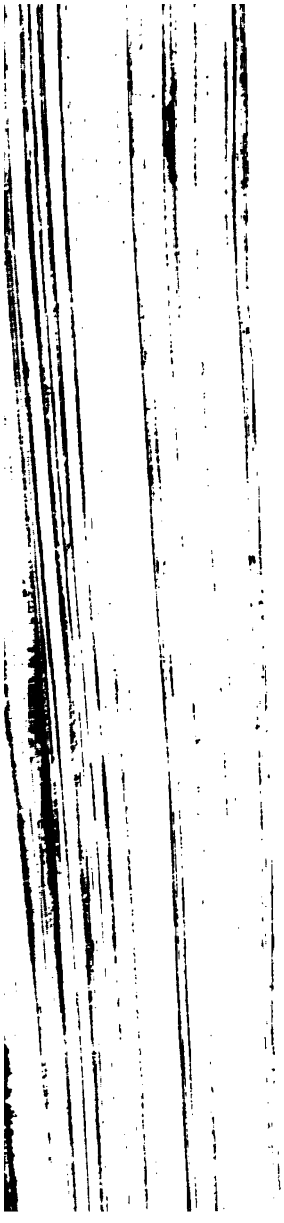
IMPROVEMENT OF CHEHALIS RIVER, WASHINGTON.

(For previous history, see page 510, Annual Report of the Chief of Engineers for 1897.)

Plan of improvement.—The plan of improvement contemplates the removal of snags, overhanging trees, jams, drift heaps, shoals, and other obstructions to navigation which may from time to time accumulate in the portion of the river regularly used by boats.

The cost of the work is indefinite.





Results obtained during fiscal year ending June 30, 1898.—The river was cleared of most of the obstructions which had accumulated during the preceding year, during which time no work had been done.

Report of operations.—Snagging operations were carried on on the river from July 6 to August 7, 1897, with an ordinary stern-wheel boat fitted up with a derrick and hoisting engine. During this time the river was cleared of all the most dangerous snags below a point about 5 miles above Montesano.

Recommendations and remarks.—From the nature of the country through which the Chehalis River runs it is liable to be blocked with snags after every freshet. To keep it open and tolerably free from obstructions to navigation it is necessary to go over it at least once a year. Heretofore the work has been almost entirely confined to the portion of the river below Montesano, and for the next 4 or 5 miles above, as this portion of the river is that principally navigated. A branch of the Northern Pacific Railroad parallels the river, and there is but little demand for any navigation farther up the river than where the work has been done. Even were the river entirely clear of snags above that point, its navigation would be difficult and dangerous on account of the swift current and shallow water. Future work will therefore be confined as heretofore to the lower part of the river. An appropriation of $3,000 is recommended as the amount which can be profitably expended on this improvement during the fiscal year ending June 30, 1899.

Future operations.—The river will be gone over and the dangerous snags removed as often as the necessity demands and funds permit.

Money statement.

July 1, 1897, balance unexpended	$1,518.01
June 30, 1898, amount expended during fiscal year	1,070.42
July 1, 1898, balance unexpended	447.59
July 1, 1898, outstanding liabilities	1.00
July 1, 1898, balance available	446.59
Amount (estimated) required for completion of existing project	Indefinite.
Amount that can be profitably expended in fiscal year ending June 30, 1900	3,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—		Act of—	
August 2, 1882	$3,000	September 19, 1890	$3,000
July 5, 1884	2,500	June 3, 1896	3,000
August 5, 1886	2,500		
August 11, 1888	2,000	Total	16,000

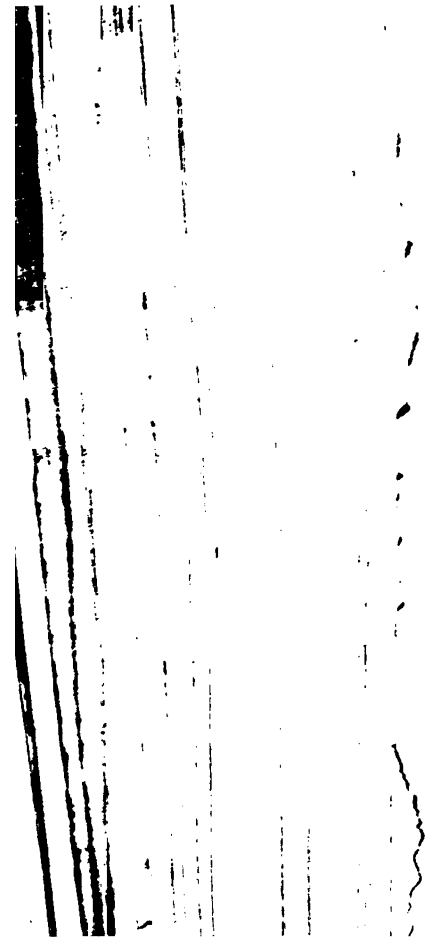
COMMERCIAL STATISTICS.

The commercial statistics for the Chehalis River were furnished by Mr. A. P. Stockwell, Aberdeen, Wash., and are for the calendar year 1897.

The export and import traffic was not given separately. It consisted principally of general merchandise and farm produce.

Five steamers were engaged in traffic whose aggregate tonnage was 669 tons and whose maximum draft was 3½ feet.

The number of passengers carried was 51,424.



With the funds that have been appropriated this snag boat an
fit have been provided, and a large number of snags, jams, overha
trees, and other obstructions to navigation removed. The obstru
now in the rivers, with those that come in with every freshet, wil
nish constant employment for the snag boat for an indefinite tim

Results obtained during the fiscal year ending June 30, 1898.—The
boat was kept continuously at work, and during the year removed
the channels of the various rivers on which she worked 8,445 s
ranging in diameter from 8 inches to 15 feet, and having an aggr
length of 218,665 feet; and cut from the banks where they are lia
fall into the streams and become obstructions to navigation 1,480
with trunks ranging in diameter from 6 inches to 8 feet, and havi
aggregate length of 128,496 feet. As a result of the snagging c
tions during the year the Skagit River was kept open for navig
throughout the year and its navigation at all seasons greatly impr
and the navigation of the other streams, when work was done, impr
Surveys of the Skagit, Duwamish, and Puyallup rivers were made
a view to determining what work, other than snagging, could a
tageously be done.

Report of operations.—The work of the snag boat was confined cl
to the Skagit River, the largest and most important river flowing
Puget Sound. During the greater part of the year her work wa
ordinary routine kind, clearing out the old snags which had acc
lated in previous years, when the stage of the river was favorabl
such work, taking out an occasional new snag wherever one was f
and trimming the banks of trees which were in danger of falling i
becoming obstructions. In the middle of November there occurre
highest water known in the Skagit River for many years. This fr
caused several very bad jams, which practically closed the riv
navigation. The snag boat immediately went to work on these j
and in a few days had openings through them sufficient for the pas
of boats, but it required constant work for over two months to
pletely clear them away, and it has been necessary to give more or
attention to the localities where the jams formed ever since on acc
of the shoaling which occurred during the time the jams remained
the consequent tendency to catch more snags.

The following is a summary of the operations of the snag boat dur

Largest diameter	feet..	15
Smallest diameter	inches..	8
Total length	feet..	218,665

Trees chopped:	
Skagit River	1,209
North Fork	13
Snohomish River	258
Total	1,480

Largest diameter	feet..	8
Smallest diameter	inches..	6
Total length	feet..	128,496

Recommendations and remarks.—The work which has been done on the rivers flowing into Puget Sound has been confined to those which flow into it from the east. These streams all have their sources in the mountains, which are covered with a heavy snowfall in the winter. The upper parts of the streams are in the nature of mountain torrents, subject to rapid fluctuations. The lower parts of the rivers have a flat slope, run through a country which was formerly completely, and is still partially, covered with heavy forests, and they generally empty into Puget Sound through a number of mouths, forming wide deltas. These conditions favor the rapid accumulation of snags and drift in the lower parts of the rivers. It is of great importance to keep these snags out for the safety of navigation and to prevent the outlets becoming completely blocked and causing disastrous overflows. To do this, it is necessary that the snag boat should be kept steadily at work.

Previous to last year there had never been sufficient money to permit of this being done, and the work accomplished had simply been to remove those snags which most interfered with navigation. During the past two years, the available funds having been sufficient to permit it, the snag boat has been kept continuously at work, with the result that the rivers worked on are now in better condition than they have been for many years. There is still work enough in sight to keep the snag boat busy for a couple of years, and with what new snags come in it will be an indefinite time before the rivers will be entirely clear. Had it not been for the snag boat's work during the past year, navigation on the Skagit River, at least, which is the most important river flowing into Puget Sound, would have been entirely suspended part of the year and carried on at great risk the remainder. This would have had an important effect on the freight rates and so on the prosperity of the country surrounding it.

The popular idea in regard to the improvement of these rivers has been that if they could be opened up so as to permit the water to flow freely through all the various channels at their mouths the floods in the valleys could be avoided. I have always doubted the correctness of this view, and as a result of a careful study of the problem during the past year, I am now thoroughly convinced that the best thing that could be done would be to close all the mouths of each river except one. The rivers carry water enough to keep one good channel open, but when the river spreads out in several channels no one keeps open, but all shoal so that they are poor channels for navigation and readily become clogged with snags. The continued snagging operations are absolutely necessary for the protection of the navigation of the rivers and the country adjacent, and for these operations alone an appropriation of $25,000 is necessary, and this amount is recommended.

Future operations.—Snagging operations will be continued and such other work done as appears advantageous and the funds permit.

Money statement.

July 1, 1897, balance unexpended	$60,026.13
June 30, 1898, amount expended during fiscal year	16,182.31
July 1, 1898, balance unexpended	43,843.82
July 1, 1898, outstanding liabilities	330.00
July 1, 1898, balance available	43,513.82

Amount (estimated) required for completion of existing project	Indefinite.
Amount that can be profitably expended in fiscal year ending June 30, 1900	$25,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—		Act of—	
June 14, 1880	$2,500	July 13, 1892	$15,000
August 2, 1882	20,000	August 18, 1894	14,000
July 5, 1884	10,000	June 3, 1896	75,000
August 5, 1886	10,000		
August 11, 1888	15,000	Total	173,500
September 19, 1890	12,000		

COMMERCIAL STATISTICS.

The following commercial statistics for the calendar year 1897 were furnished by Lilly, Bogardus & Co., the La Conner Trading and Transportation Company of Seattle, Wash., and Mr. F. H. Brownell, manager, Everett Land Company, of Everett, Wash.:

Exports and imports (Skagit River).

Class of goods.	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Grain	3,615	$72,300		
Hay	4,200	33,600		
Merchandise	987	63,180	3,120	$154,50
Total	8,802	169,080	3,120	154,50

Three steamboats plied most of the year on the Skagit River; average tonnage, 198 tons; average draft, 5 feet; maximum draft, 7 feet.

Passengers carried, 4,926.

On the Snohomish River, five steamboats were engaged in passenger and freight traffic, and in towing.

Twenty-four thousand eight hundred and three passengers were carried between Everett and Snohomish.

Fifteen million feet of logs were floated down the Snohomish River.

REPORT OF MR. E. H. JEFFERSON, MASTER OF SNAG BOAT.

U. S. SNAG BOAT SKAGIT,
Mount Vernon, Wash., July 16, 1898.

CAPTAIN: I have the honor to submit the following report of operations of the snag boat at "Improving Puget Sound and tributary waters, Washington, for the fiscal year ending June 30, 1898."

At the commencement of the year the snag boat was operated on the Snohomish River, where she continued working till August 16, on which date she left for the Skagit River, stopping at the mouth of the Stillaguamish on the way, where two days were devoted to clearing the channel of snag obstructions. August 19 operations were commenced on the Skagit River and prosecuted till October 25, during

which time the snag boat was used by Assistant Engineer Clapp, to make the necessary soundings on the Skagit tide flats, to complete his survey of the river.

On the 25th October a trip was made to Sullivan Slough and the North Fork of the Skagit, where certain obstructions were removed. Return was made to the Skagit on the 27th, and work prosecuted there till December 22, when another trip was made to the Stillaguamish for the purpose of removing obstructions from the channel in the vicinity of Stanwood deposited by recent freshet. The boat returned to the Skagit again the next day, and operations continued there till March 1, 1898, on which date a trip was made to Hat Slough and the mouth of the Stillaguamish; the entrance to these two streams were cleared of obstructions, and on the 4th of same month the snag boat again returned to the Skagit, where work was resumed and continued till the 31st same month, when another trip was made to the Stillaguamish, and the north and south forks of that river again cleared of obstructions; returning to the Skagit River on April 1, operations there were continued till June 16, when another trip to the Stillaguamish occurred. After clearing the channel at the mouth of this stream again the snag boat returned to the Skagit, where work was prosecuted till the end of the fiscal year.

During this period a great deal of important work has been done and some of the heaviest work the snag boat has ever done. The different rivers and sloughs of the district have been kept clear of accumulating obstructions and navigation made safer and easier.

During the month of November, 1897, the greatest freshet the Skagit River ever experienced occurred, which in addition to doing great damage to settlers along the river caused two formidable jams of drift to form in the river, completely blocking navigation—one at the Great Northern Railway crossing and the other down near the river's mouth, at tide water, the latter being the largest, filling the stream from bank to bank for a distance of about 800 yards.

In some places it was packed clear to the bottom of the channel with débris of every description, consisting principally of immense stumps, some of which would average 16 feet in diameter, and giant spruce trees 200 feet and more long, with innumerable limbs and branches, some of which were as large as ordinary trees. Pile dolphins, bridge piers, sections of houses and barns, barbed-wire fences, and booms of saw logs were component parts of this jam. It took a month or more to completely break up this jam, during which time a side channel or slough was improved so as to serve the purposes of navigation temporarily.

The jam at the Great Northern Railway crossing was broken in about a week's time. If it had not been for the snag boat, navigation in the Skagit River would be closed yet and thousands of acres of tillable farm lands overflowed and ruined.

During the seasons of low water the channels of the Skagit and other rivers have been pretty thoroughly cleared of snags as far as steamboats generally go, and during this summer's high water the overhanging trees in the bends that are continually eroding have been chopped down, trimmed, and sectioned as far upstream in the Skagit as practicable, and many side jams of drift have been broken up also.

I consider that the work of the snag boat has been very beneficial this year; in fact I do not see how her services could have been dispensed with. River men in general speak in complimentary terms of the good work she performed last winter after the flood.

The towing of logs from upriver points has never been so easy and safe as at present. It is now done by boats of light power that would not attempt it a few years ago.

The regular steamer from Seattle has recently been making or extending her trips to Sedro for the first time in years, and I understand has brought the railroad rates to that point down a few pegs, all of which is an indication of a better and easier river to navigate; but it requires the constant attention of the snag boat to maintain these conditions.

It will be noticed by the foregoing record that the greater part of the boat's time is spent on the Skagit River; this is because the Skagit is the largest and most important of all the rivers of this district. More drift and obstructions are brought down by the periodical freshets of this river than that of all the other streams combined, and consequently more work is required to keep it safe for navigation.

Following is a summary of the work between the dates of June 30, 1897, and June 30, 1898:

Number of snags and drift disposed of:

Skagit River	7,828
Snohomish River	453
Stillaguamish River	125
Hat Slough	23
Sullivan Slough	5
North Fork, Skagit	11
Total	8,445

Total length	feet	218,665
Largest diameter	do	15
Smallest diameter	inches	8
Number of trees chopped from the banks:		
Skagit River		1,209
Snohomish River		258
North Fork, Skagit		13
Total		1,480
Total length	feet	128,496
Largest diameter	do	8
Smallest diameter	inches	6

In addition to the regular snagging operations the boat has been kept cleaned and repaired, and the tools and gear kept in working order.

On the Skagit River at present two steamers are regularly employed, one of them making three trips per week from Seattle via Stillaguamish River points. This boat goes as far as Sedro, 25 miles from the mouth of river, and occasionally farther. The other one is engaged in log towing almost exclusively, from points as far up as Lyman, 36 miles.

The Snohomish River has three steamers employed regularly—one from Seattle twice per week; one between the cities of Everett and Snohomish, three trips per day, and the other from Snohomish to upriver points on the Snohomish and Snoqualmie rivers, when business and the stage of water serve.

The Nooksack River is still blocked by jam at its mouth and no boats find business there.

The Skagit River boat generally does the business for the Stillaguamish River, though there is a towing boat that makes its headquarters at Stanwood.

The Duwamish River has no regular steamboat; jobbing boats occasionally go up as far as the head of tide water after hay and other produce.

The character of the freight carried by all of these boats is principally farm produce and general merchandise. A great many passengers are transported by some of them.

During the season when the crops of oats and hay are transported to market several irregular or jobbing boats find profitable employment from the many tidal sloughs composing the delta of the Skagit and Snohomish rivers, and from the main rivers, too.

Very respectfully, your obedient servant,

E. H. JEFFERSON,
Master of Snag Boat.

Capt. HARRY TAYLOR,
Corps of Engineers, U. S. A.

V V 5.

IMPROVEMENT OF HARBOR AT OLYMPIA, WASHINGTON.

(For previous history, see page 512, Annual Report of the Chief of Engineers for 1897.)

Plan of improvements.—It is proposed by the plan of improvement adopted to dredge a channel 250 feet wide and 12 feet deep at the mean of the lower low waters from the vicinity of the Fourth Street Bridge to deep water in Budd Inlet. Near its inner end the channel is to be widened out to 500 feet, so as to provide a turning basin for boats using it.

The estimated cost of the work was $275,000.

Report of operations.—There were no operations and no results obtained during the fiscal year ending June 30, 1898.

A report on a survey of the Deschutes River at its entrance in Olympia Harbor was submitted.

Recommendations and remarks.—The importance of Olympia lies in the fact that it is the capital of the State. The only commerce carried on by water is the local commerce between Olympia and other cities on

Puget Sound. This local traffic is carried by the ordinary light-draft stern-wheel boats, and as the depth and width of channel and basin already secured are ample for the accommodation of this class of boats, the project is completed, as far as the main and immediate benefit to the city is concerned. The projected depth is 12 feet at "mean lower low water." The datum used in the determination of the depths obtained by dredging is "extreme low water." The relation between these two planes does not seem to have been established at the time the project was made, but recent observations indicate that "extreme low water" is about 2 feet below "mean lower low water." Such being the case the project is completed, so far as the basin is concerned. There are practically no boats plying in these waters, except possibly towboats, with a draft between that of the boats now running to Olympia and that of the deep-draft coasting vessels, 20 feet or more. If the latter class of vessels is to be accommodated, for which there appears to be no reason at present, the projected depth should be increased. If not, the depths already obtained in the basin and in the outer end of the channel will serve practically every purpose which depths 2 feet greater will. It might, however, be of some slight advantage to increase the depth throughout the part of the channel now 6 feet deep to 8 feet, so as to have all parts of the channel of a uniform depth. It is also probable that there will be some shoaling of the depths already obtained, and as it is important to maintain these depths, an appropriation of $20,000 is recommended as the amount that can be profitably expended during the fiscal year ending June 30, 1899.

Future operations.—Future work will depend upon the funds appropriated.

Money statement.

July 1, 1897, balance unexpended	$3,074.12
June 30, 1898, amount expended during fiscal year	842.57
July 1, 1898, balance unexpended	2,231.55
July 1, 1898, outstanding liabilities	4.47
July 1, 1898, balance available	2,227.08
Amount (estimated) required for completion of existing project	168,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	20,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
July 13, 1892	$35,000
August 18, 1894	40,000
June 3, 1896	32,000
Total	107,000

COMMERCIAL STATISTICS.

Olympia Harbor is in the collection district of Puget Sound.

The returns were furnished by the Olympia Chamber of Commerce, Charles D. King, secretary.

There are three steamboats engaged in traffic on the Olympia Harbor, with an aggregate tonnage of 601 tons.

The maximum draft of the vessels is 4 feet.

Exports and imports.

Class of goods.	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Val
	Tons.		*Tons.*	
Beer	720	$57,600		
Grain	60	1,200	600	$1
Hay	50	400		
Hops	100	16,000		
Live stock	140	7,000		
Lumber and products	22,490	66,000	300	1
Meats, dressed	125	17,500		
Merchandise, general	1,515	105,700	2,500	11
Shellfish	1,200	40,000		
Total	26,400	312,400	3,400	12

V V 6.

IMPROVEMENT OF WATERWAY CONNECTING PUGET SOUND WITH LAKES UNION AND WASHINGTON.

(For previous history, see page 513, Annual Report of the Chief Engineers for 1897.)

The river and harbor bill of September 19, 1890, contained an it directing the appointment of a board of three officers of the Corps Engineers upon whom should devolve the duty of selecting and su veying the most feasible location and of estimating the expense constructing a ship canal to connect the waters of Lakes Union, Was ington, and Sammamish with Puget Sound, and appropriating $10,0 for the necessary expenses.

Plan of improvement.—The plan outlined in the report of the boa consisted in dredging a channel through the flats of Shilshole Bay fro deep water in Puget Sound to the mouth of Salmon Bay, and the building a lock to overcome the differences of elevation between th Sound and Lake Union.

The lock with a dam would bring the waters of Salmon Bay to th elevation of Lake Union.

The plan further provided for dredging in Salmon Bay to give th requisite depth for a deep-sea harbor, and for the dredging of a can to connect Salmon Bay with Lake Union, and the necessary dredging in Lake Union to reach the head of the lake. Communication betwee Lakes Union and Washington was provided for by a canal with a loc to overcome the difference of elevation between the lakes, and by dredging through the shallows of Lake Washington to deep water.

A variation of the plan was to throw a dam across the outlet of Sa mon Bay and dig a canal from Salmon Bay to Smiths Cove, and then dredge a channel to deep water in Elliott Bay, building a lock to over come the difference of level between the waters of Elliott Bay and Lak Union.

The total length of the waterway from the inner end of the lock nearest Lake Washington to the outer end of the lock nearest Puget Sound will be about 6.2 miles by the Shilshole Bay route and somewhat less by the Smiths Cove route.

The estimated cost of a double-track canal, with masonry locks, and including the necessary right of way, was $2,900,000 by the Shilshole Bay route, or $3,500,000 by the Smiths Cove route; and of a single track canal, with composite locks, and exclusive of any right of way,

was $1,781,167 by the Shilshole Bay route, or $2,316,167 by the Smiths Cove route.

Since the original estimates of the cost of this improvement were made several changes in the plan have been adopted, all of which materially affect the cost, and the original estimates can no longer safely be considered even approximate. It is probable, however, that an estimate at the present time would be less than the original maximum estimate.

No funds have been available for the preparation of plans or for carrying on the work required before an estimate can be properly made, and so no estimate is attempted.

Report of operations.—Under the date of March 1, 1898, a board of officers, consisting of Capt. W. L. Fisk, Capt. Harry Taylor, and Lieut. Chas. L. Potter, all of the Corps of Engineers, was appointed by the authority of the Secretary of War to consider and report upon the most feasible route for this waterway, with special reference to the terminal point at the Sound end.

Under date of March 23, 1898, the above Board submitted a report recommending that the waterway enter Puget Sound through Shilshole Bay, and that the outer lock be drawn back about 2,000 feet from the location given by the former Board. These recommendations were approved and what is known as the Shilshole Bay route adopted by the Secretary of War under date of April 14, 1898.

During the year the county commissioners of King County have been acquiring the title to the land needed for the right of way and obtaining releases from damages from the lands which will be affected by the construction of the waterway, for the purpose of transferring them to the United States free of cost, as required by the act of August 17, 1894, making the first appropriation for this work, which contained the following clause:

> No part of said amount shall be expended on the improvement of the waterway connecting the waters of Puget Sound with Lakes Union and Washington until the entire right of way and release from all liability to adjacent property owners have been secured to the United States free of cost and to the satisfaction of the Secretary of War.

These proceedings have now advanced so that the county prosecuting attorney states that he expects to have the title to all the right of way and all the releases from damages ready to transfer to the United States about August 1, 1898.

Recommendations and remarks.—As no money has been available for work on detailed plans, no consideration has been given them. It is probable that the title to the right of way and the required releases from damages will be transferred to the United States within a short time, and actual construction can be commenced as soon as proper detailed plans are prepared. The selection of the Shilshole Bay route and the change in the location of the lock materially reduce the uncertainties connected with the plans and put the general project in such a shape that some work can safely be commenced soon after the title to the right of way is transferred to the United States. But before anything except a little excavating can safely be undertaken full plans must be prepared. This will be an undertaking of some magnitude, and if any construction work is commenced in advance of the completion of such plans there is a possibility of changes being required, making unnecessary expense and eventually delaying the completion of the work.

Future operations.—As soon as the money becomes available detailed plans will be prepared. The amount of money that can profitably be spent upon this improvement during the next fiscal year depends upon the time actual construction can be commenced. If it is commenced early in the year, $200,000 can be profitably expended in addition to the amount on hand.

Money statement.

July 1, 1897, balance unexpended	$170,000.00
July 1, 1898, balance unexpended	170,000.00
Amount (estimated) required for completion of existing project	Uncertain.
Amount that can be profitably expended in fiscal year ending June 30, 1900	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—	
August 18, 1894	$25,000
June 3, 1896	150,000
Total	175,000

COMMERCIAL STATISTICS.

The following commercial statistics for the calendar year 1897, pertaining to the commerce of Seattle and Ballard, Wash., were compiled from information furnished by The Trade Register of Seattle.

SEATTLE SHIPPING.

Forty-seven vessels are engaged in the regular traffic of this port, consisting of 13 steamships, 31 steamers, 2 barks, and 1 ship. The gross tonnage is 37,248 tons.

The statistics show but little of the local commerce carried on by the above vessels, as no record of their cargoes has been kept.

The arrivals of steam vessels were 302, and of sail vessels 102. The departures were the same. The registered net tonnage was 441,980.

Twenty steam and 17 sail vessels were constructed during the year, with an aggregate gross tonnage of 2,481 tons.

Exports and imports (water shipments).

Class of goods.	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Cotton	4,515	$728,186		
Coal	287,883	863,649		
Fish			5,190	$364,000
Flour	11,530	374,637		
Wheat	40,133	1,037,358		
Lumber and shingles	65,515	376,578		
Tea			2,684	724,085
Miscellaneous	78,809	7,880,900	67,642	6,764,200
Total	488,385	11,261,308	75,516	7,852,285

V V 7.

IMPROVEMENT OF EVERETT HARBOR, WASHINGTON.

(For previous history, see page 515, Annual Report of the Chief of Engineers for 1897.)

Plan of improvement.—The plan of improvement adopted for this work may be generally described as follows:

First, to excavate a harbor basin in the shallows and tide lands adjoining deep water near the river's mouth; second, to dredge a channel from this through the tide flats and the Old River mouth to deep fresh water in Snohomish River, this channel being designed to bring fresh water to the harbor basin and to afford facilities for navigation about the peninsula and into the deep water bounding the peninsula on the east; and, third, to protect and maintain this harbor and channel across the tide flats by a bulkhead interposed between them and the open waters of the sound, the bulkhead to act as a retaining wall for the material dredged from the harbor.

The proper conduct of the work required that the bulkhead for retaining the dredged material should be built previous to doing any dredging. A map of Everett Harbor, showing the plan of improvement, was published in the Report of the Chief of Engineers for 1895, opposite page 3434.

The estimated cost of the improvement is $372,000.

Results obtained during the fiscal year ending June 30, 1898.—No work was done during the fiscal year ending June 30, 1898, and no results were obtained.

Recommendations and remarks.—No material benefit has resulted from the work done thus far, and none will result until the channel has been dredged through the flats from deep water outside to deep water inside. Until the dike is backed up with the dredged material, repairs will be necessary with every appropriation. Therefore, the longer the work is in being completed the longer will the benefits to be received from it be delayed and the more the work will cost.

The commercial statistics for Everett Harbor were this year again furnished by Mr. F. H. Brownell, and as usual were very complete and satisfactory.

An appropriation of $150,000 is recommended as the amount which can be profitably expended on the project during the fiscal year ending June 30, 1900.

Future operations.—The dike will be repaired and added to from time to time as may be necessary, and the dredging continued, so as to give such relief to shipping as the funds will permit.

Money statement.

July 1, 1897, balance unexpended	$791.77
June 30, 1898, amount expended during fiscal year	316.50
July 1, 1898, balance unexpended	475.27
July 1, 1898, outstanding liabilities	.71
July 1, 1898, balance available	474.56
Amount (estimated) required for completion of existing project	342,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	150,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.

Appropriations.

Act of—	
August 18, 1894	$10,000
June 3, 1896	20,000
Total	30,000

COMMERCIAL STATISTICS.

Everett is in the collection district of Puget Sound, and is a subport of entry.

The following returns were furnished by Mr. F. H. Brownell, vice-president Everett Land Company, and are for the calendar year 1897.

There are 4 seagoing steamers of the propeller type, with an aggregate tonnage of 7,920 tons, and 15 river steamers, mostly of the stern-wheel class, with an aggregate tonnage of about 2,000 tons, that are engaged in the Everett commerce.

The maximum draft of the steamers is 24 feet.

The number of passengers carried during the year was 64,980.

Exports and imports (water shipments).

Class of goods.	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Bleaching powder			400	$25,000
Box shooks	9,000	$24,000		
Bullion	4,000	1,400,000		
Coke			7,000	42,000
Grain, feed, etc	2,625	52,500		
Lime rock			2,500	11,000
Lumber and products	9,511	31,342		
Merchandise, general			10,679	800,225
Nails	2,853	116,361		
Ore			15,000	240,000
Paper	2,100	163,338		
Wire rods			2,292	68,760
Total	30,089	1,787,541	44,871	1,186,985

V V 8.

IMPROVEMENT OF SWINOMISH SLOUGH, WASHINGTON.

(For previous history, see page 516, Annual Report of the Chief of Engineers for 1897.)

Plan of improvement.—The plan of improvement adopted is to dredge a channel 4 feet deep and 100 feet wide from deep water in Saratoga Passage across Skagit Flats, through the shoals of the slough proper, and across the flats of Padilla Bay to deep water, and to build dikes in Skagit and Padilla bays to direct the ebbing and flooding waters through the dredged channels.

The estimated cost of the work is $122,000.

A report of a survey of Swinomish Slough, upon which the plan of improvement is based, is printed with a general map in House Ex. Doc. No. 31, Fifty-second Congress, first session, and reprinted without map in the report of the Chief of Engineers for 1892, pages 2753–2762.

Maps showing parts of the improvement are also published in the Report of the Chief of Engineers for 1894, opposite page 2615, and for 1896, opposite page 3377.

Results obtained during the fiscal year ending June 30, 1898.—A short spur dike was added to the dike between McGlinns Island and Gallahers Point.

Report of operations.—During September and October, 1897, a spur dike 796 feet long was built for the purpose of scouring away a shoal

which had formed in the channel a short distance inside the "Hole in the Wall." There were placed in this dike 4,834 linear feet piling, 105.6 cords of brush fascines, 148.1 cords brush, 650 pounds wire, 17,000 feet B. M. lumber, 1,740 pounds spikes, and 453,26 tons of stone, at a total cost of $1,499.09.

Recommendations and remarks.—The work done the past year completes the work contemplated by the project as far as Laconner, the principal town on Swinomish Slough, and considerable immediate benefit is derived from the work already done; but as all the work so far done has been on the southern half of the slough, no benefit is derived by boats having their destination north of Laconner.

The route through Deception Pass and around the west side of Fidalgo Island is a particularly dangerous one, as the island is high and cuts off the wind to such an extent that a severe wind may be blowing outside and but little intimation of it felt on the inside. At certain stages the tide running through Deception Pass resembles a mountain torrent more than a tidal flow. On the ebb this tide running into a west wind raises a dangerously heavy sea. A boat once started through the Pass can not turn back, but must go through and meet whatever sea there may be on the outside.

It is therefore very desirable that the slough be fully opened with the least delay practicable, and it is recommended that the full amount to complete the project be appropriated.

Future operations.—Work in accordance with the project will be extended north of Laconner as fast as available funds permit.

Money statement.

July 1, 1897, balance unexpended	$2,169.75
June 30, 1898, amount expended during fiscal year	2,005.61
July 1, 1898, balance unexpended	164.14
July 1, 1898, outstanding liabilities	9.00
July 1, 1898, balance available	155.14
Amount (estimated) required for completion of existing project	47,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1900	47,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of June 4, 1897.	

Appropriations.

Act of—	
July 13, 1892	$25,000
August 18, 1894	25,000
June 3, 1896	25,000
Total	75,000

COMMERCIAL STATISTICS.

Swinomish Slough is in the collection district of Puget Sound. The nearest port of entry is Port Townsend, Wash.

The following statistics were furnished by Mr. John Polson, treasurer of the Laconner Board of Trade, and are for the calendar year 1897:

One daily, and a number of transient steamers are engaged in traffic at this point. The average tonnage is about 250 tons. The maximum draft is 10 feet.

Six thousand passengers were carried during the year.

No new industries have been reported.

Exports and imports.

	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Agricultural implements			850	$60,000
Butter	100	$30,000		
Cabbage seed	20	10,000		
Eggs	15	2,000		
Flour	200	8,000		
Fruit	40	1,000	500	12,000
Fish	1,500	60,000		
Furs	2	5,000		
Grain	20,000	400,000		
Hay	5,000	50,000		
Hides	50	10,000		
Hops	50	8,000		
Live stock	1,500	75,000		
Lumber	11,250	60,000		
Merchandise			3,400	340,000
Potatoes	5,000	40,000		
Wood, cord	15,000	15,000		
Wool	2	4,000		
Total	59,729	778,000	4,750	412,000

V. V 9.

IMPROVEMENT OF KOOTENAI RIVER, IDAHO, BETWEEN BONNERS FERRY AND THE INTERNATIONAL BOUNDARY LINE.

The appropriation for this work was made in the river and harbor act of June 3, 1896.

Description of original condition.—The portion of the Kootenai River for which this appropriation is available is about 60 miles in length, has a gentle current, and a depth sufficient for navigation, but was obstructed by many snags, which had lodged in the river.

A description of this part of the river is published in the Report of the Chief of Engineers for 1893, pages 3456–3458.

Plan of improvement.—The plan of improvement is to remove the snags in the river and the leaning trees on the banks which are liable to fall in and become obstructions.

The estimated cost of the improvement is $5,000.

Results obtained during the fiscal year ending June 30, 1898.—The entire stretch of river embraced within the limits of the project was worked over and all the snags in the channel taken out.

Report of operations.—Snagging operations were carried on from August 14 to September 22, 1897, during which time 401 snags were removed from the river.

Recommendations and remarks.—At the time snagging operations were suspended, the channel had been practically cleared of snags, but from the nature of the stream and the surrounding country it is certain that other snags will accumulate with every high water. The balance of the appropriation will suffice for only one more general clearing out of the channel and in a few years the stream will again be filled with snags. With the advent of the railroads the importance of this part of the Kootenai River as a navigable stream has greatly diminished, and only an occasional boat now plys on this stream, and such boats as there are are all of British register.

As the appropriations amount to the estimated cost of improvement, no recommendation is made in regard to future appropriations.

Future operations.—Whenever it may be necessary the snags in the river will be taken out so long as the funds last.

Money statement.

July 1, 1897, balance unexpended	$2,836.97
June 30, 1898, amount expended during fiscal year	2,091.51
July 1, 1898, balance unexpended	745.46

Appropriation.

Act of June 3, 1896	$5,000

COMMERCIAL STATISTICS.

The commercial statistics for this improvement were furnished by Mr. F. M. Lucas and David G. Browne, collector of customs, and are for the calendar year 1897.

Exports and imports.

	Exports.		Imports.	
	Quantity.	Value.	Quantity.	Value.
	Tons.		*Tons.*	
Grain	400	$8,000	.....	.....
Hay	500	5,000	.....	.....
Lumber	350	1,000	.....	.....
Fruit and vegetables	603	14,500	.....	.....
Wood	150	500	.....	.....
Furs	1	10,000	.....	.....
Miscellaneous	178	8,525	30	$1,500
Total	2,182	47,525	30	1,500

Of the above values, $39,306 worth of exports and $1,104 worth of imports passed through the hands of the collector of customs, port of Great Falls, Mont.

Two sawmills with a capacity of 90,000 feet of lumber and 50,000 shingles per day have been built at Bonners Ferry, and a stone quarry opened 1 mile below.

Ten steamboats ply on this part of the river whose tonnage runs from 7 to 320 gross tons. The maximum draft is 3 feet 6 inches.

V V 10.

IMPROVEMENT OF KOOTENAI RIVER, ABOVE JENNINGS, MONTANA.

Description of original condition.—The Kootenai River between Jennings and the international boundary line, a distance of 65 miles, is fairly good for purposes of navigation. At extreme low water it is obstructed at several places by shoals over which there is not sufficient water for navigation. At the higher stages the only obstruction of any consequence was in a canyon about 5 miles above Jennings, where the rock walls of the river approach each other to such an extent as to produce a very marked damming effect upon the river, causing a heavy fall and swift currents. Large rocks were scattered about in the river and along the shores rendering the ascent of boats difficult and the descent extremely dangerous. The best channels through the rocks were about 80 feet wide.

Plan of improvement.—The project adopted for this improvement is to break up and remove the dangerous rocks, and by cutting off the points which produce the damming effect so increase the channel as to

season of the year. Work was started on October 29, and finishe November 26, 1897. The work was considerably interfered with unusually cold weather and an almost unprecedented rise in the r for that season of the year, but all the work planned for that fall accomplished. During the time work was in progress, there v removed and disposed of 1,859 cubic yards of rock, increasing the wi of the river at high water from 150 feet, its original width, to 200 f

Recommendations and remarks.—The rocks which were particula complained of when the project was made were all removed last seas The removal of those rocks will undoubtedly cause such a change the currents as to make other rocks obstructions under the chan conditions which were formerly not noticeably in the way. One s son's navigation will develop what additional work is needed, and t balance of the appropriation will suffice for this additional work.

The appropriation amounts to the estimated cost of the work. recommendation is made in regard to future appropriations.

Future operations.—Such rocks as may prove to be obstructions v be removed.

Money statement.

Amount allotted by act of July 19, 1897	$5,000
June 30, 1898, amount expended during fiscal year	3,56
July 1, 1898, balance unexpended	1,43
July 1, 1898, outstanding liabilities	1
July 1, 1898, balance available	1,42

Appropriation.

Act of July 19, 1897	$5,0

COMMERCIAL STATISTICS.

The following commercial statistics were furnished by Mr. J. D. Miller and Da G. Browne, collector of customs, and are for the calendar year 1897:

Exports and imports.

No previous report of statistics has been made for this work.

Of the above values $42,373 worth of exports and $127,548 worth of imports passed through the hands of the collector of customs, port of Great Falls, Mont.

Three steamers plied on the river part of the year—the *North Star*, 379 tons; *Gwendoline*, 158 tons, and *Ruth*, 368 tons. The maximum draft is 3 feet 6 inches.

One thousand and eighty-seven passengers were carried.

The steamers *Gwendoline* and *Ruth* were wrecked on May 7, 1897.

V V II.

IMPROVEMENT OF FLATHEAD RIVER, MONTANA.

The first appropriation for this work was made in the river and harbor act of June 3, 1896.

Description of original condition.—The portion of the Flathead River included within the limits for which this appropriation is available is about 27 miles in length. This portion of the river is of very gentle slope, running with many turns through a large area of low-lying lands, and has a minimum depth of about 10 feet, but is obstructed by a large number of snags which have accumulated in the river.

Plan of improvement.—The plan of improvement is to remove the snags. The language of the act making the appropriation is as follows:

> Improving Flathead River, Montana, ten thousand dollars, which sum shall be expended in snagging from Demersville to the Flathead Lake, in accordance with the plan submitted in the Annual Report of the Chief of Engineers for eighteen hundred and ninety-five.

No estimate of the cost of this improvement has been made, and from its nature none can be made.

A description of this work is given in the Report of the Chief of Engineers for 1895, pages 3480–3484.

Results obtained during fiscal year ending June 30, 1898.—The entire stretch of river within the limits of the project was worked over and the greater part of the worst snags removed.

Report of operations.—Snagging operations were carried on from September 39 to November 25, 1897, when they were suspended on account of the freezing up of the river, and from March 16 to April 28, 1898, when they were suspended on account of high water. The snagging was done with a small stern-wheel boat fitted up with an "A" frame, tackle, and a hoisting engine. During the time the work was carried on there were removed from the river 846 snags.

Recommendations and remarks.—The entire stretch of river embraced within the limits of the project has been worked over and the greater part of the snags which were obstructions to navigation removed for less than half the sum already appropriated. The river can be thoroughly cleared of all the obstructions now in it with part of the balance of the appropriation, but from the nature of the river and the surrounding country new snags will soon come in and form new obstructions, so that the river must be occasionally gone over in order to keep it in proper shape. The funds on hand will, however, be sufficient to keep the river clear for the next two years, and no appropriation is recommended for this improvement for the fiscal year ending June 30, 1900.

Future operations.—The remaining snags in the river will be taken out and the river kept clear so long as the funds will permit.

Money statement.

July 1, 1897, balance unexpended	$10,000.00
June 30, 1898, amount expended during fiscal year	4,471.03
July 1, 1898, balance unexpended	5,528.97
July 1, 1898, outstanding liabilities	10.00
July 1, 1898, balance available	5,518.97

Amount (estimated) required for completion of existing project ..... Indefinite.
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867.

Appropriation.

Act of June 3, 1896 ..... $10,000

COMMERCIAL STATISTICS.

The following statistics for the calendar year 1897 were furnished by Mr. George F. Stannard, Kalispell, Mont.:

But one steamer, with a draft of 3 feet, is engaged in traffic on the river and lake, and the business of the steamer is not classed as exports and imports.

Three hundred and sixty-three tons of freight, consisting of general merchandise, lumber, hay, and grain, and 282 passengers were carried between local points.

Owing to the snagging operations on the river, some 20,000 ties were run out, and this will probably constitute one of the industries of the country.

V V 12.

PRELIMINARY EXAMINATION OF NEAH BAY, WASHINGTON, WITH A VIEW TO ITS IMPROVEMENT AS A HARBOR OF REFUGE.

[Printed in House Doc. No. 139, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 6, 1897.

SIR: I have the honor to submit the accompanying report of November 10, 1897, with map,* by Capt. Harry Taylor, Corps of Engineers, of the results of a preliminary examination of Neah Bay, Washington, with a view to its improvement as a harbor of refuge, made to comply with the requirements of the river and harbor act of June 3, 1896.

Captain Taylor states that from the conditions under which the commerce passing through the Straits of Fuca is carried on, as described in his report, and the number of wrecks which have occurred, it seems that this commerce does frequently need a harbor of refuge; that Neah Bay is the best and most suitable place for such a harbor of refuge; that in his opinion the locality is worthy of improvement "as a harbor of refuge," and that the improvement is justified by the interests of commerce involved. His views are concurred in by the Division Engineer, Col. Chas. R. Suter, Corps of Engineers.

*Not reprinted. Printed in House Doc. No. 139, Fifty-fifth Congress, second session.

It is estimated that a survey necessary for preparation of plans and estimates for improvement will cost $500, and in my opinion the conditions justify such a survey as will furnish the detailed information necessary for determining the cost of the proposed work and its relation to the interests of commerce involved.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., November 10, 1897.

GENERAL: I have the honor to submit the following report of a preliminary examination of Neah Bay, Washington, "with a view to its improvement as a harbor of refuge," made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of June 16, 1896.

The advisability of improving Neah Bay so as to convert it into a harbor of refuge depends upon several considerations, principal among which are:

First. Whether any harbor of refuge is needed in the general locality.

Second. If a harbor of refuge is needed, is Neah Bay the best and most suitable place for it?

Third. The cost of constructing a harbor of refuge at Neah Bay.

Whether any harbor of refuge is needed will depend upon the amount of commerce in the vicinity which might seek such a harbor in case of need, and whether the conditions are such as to make it probable that such cases of need would often happen if the commerce were there.

Neah Bay is located at the outer end of the Strait of Fuca, through which passes practically all of the deep-sea shipping arriving at or departing from Puget Sound or British Columbia ports. Enormous quantities of lumber and coal are continually being exported, and during the fall and winter large quantities of wheat are also exported. In addition to carrying these exports and the miscellaneous merchandise imported for local consumption, the shipping passing through the strait has direct connection with three transcontinental railroads—the Northern Pacific, the Great Northern, and the Canadian Pacific. Each one of these railroads has a separate and independent transpacific connection.

The present indications are that the commerce passing through the straits will rapidly and constantly increase in volume and value in the future. Within the past year a new steamship line between Seattle and Japan has been established. The gold finds in Alaska within the past few months seem to point to a large commerce with that Territory in the near future, much of which will pass through the straits.

I give here a summary of the arrivals at and departures from United States ports for the two years ending June 30, 1897. This list was furnished through the kindness of Col. H. D. Heustis, collector of customs, Port Townsend. This represents the tonnage entering and clearing at United States ports only. It is probable that a similar list for British Columbia ports would show a tonnage nearly equal to this.

Clearances July 1, 1895, to June 30, 1897.

	Steam vessels.	Sailing vessels.	Hailing for foreign ports.	Hailing for domestic ports.	Total clearing.	Tonnage, foreign.	Tonnage, domestic.	Total tonnage cleared.
Total for last six months, 1895.....	1,013	107	1,120	99	1,219	636,871	107,579	744,450
Total for first six months, 1896.....	869	140	1,009	150	1,159	540,814	120,861	661,675
Total for last six months, 1896.....	1,163	144	1,307	119	1,426	603,749	117,069	720,818
Total for first six months, 1897.....	888	112	1,000	115	1,115	552,904	109,775	662,679
Grand total..	3,933	503	4,436	483	4,919	2,334,338	455,284	2,789,622

Entered July 1, 1895, to June 30, 1897.

	Steam vessels.	Sailing vessels.	Hailing from foreign ports.	Hailing from domestic ports.	Total entering.	Tonnage, foreign.	Tonnage, domestic.	Total tonnage entered.
Total for last six months, 1895.....	1,016	78	1,094	139	1,231	589,300	144,341	733,641
Total for first six months, 1896.....	858	82	940	147	1,087	485,471	148,589	634,060
Total for last six months, 1896.....	1,166	157	1,323	140	1,463	629,612	121,905	751,517
Total for first six months, 1897.....	878	92	970	123	1,093	518,069	128,163	646,232
Grand total..	3,918	409	4,327	549	4,874	2,222,452	542,998	2,765,450

It thus appears that the commerce in the locality is a large and growing one. Are then the conditions such as to make it probable that this commerce would be likely to need the harbor?

Throughout the Straits of Fuca there is an abundant depth of water and very few dangers in the way of rocks isolated from the shore.

The real dangers which beset vessels come from thick weather, fog, rain, and smoke, which are very prevalent; winds; the set and strength of the heavy cross seas off the entrance, which departing vessels must encounter or return some 50 miles to a place of safety; and the lack of anchorage and sheltered positions to which to retire in case of storm or trouble.

About the entrance to the strait the rainfall is very great; at Neah Bay it averages about 100 inches per year, while it has been known to rain 132 inches in a single year.

At Port Townsend and Victoria, at the eastern end of the strait, the rainfall is only about 20 inches per year.

When not raining about the entrance it is apt to be very foggy, the foggiest months being July, August, and September. The fogs are densest near the entrance, and decrease in frequency and intensity toward the inner end of the straits.

Added to the rain and fog is a dense smoke which hangs over the country, often for considerable periods. This comes from forest fires and clearing fires about the straits and Sound.

This prevalence of thick weather indicates the desirability and necessity of a multiplicity of guiding signals along the shore of the straits.

During the summer but little trouble is experienced from the winds, but in winter the strong southeast winds draw directly out and create a very heavy cross sea off the entrance, the great southwest swell meeting that going out.

In such cases sailing vessels going out to sea are in great peril. The alternative is to put back to Port Angeles or Royal Roads, some 50 miles, and wait for a change of wind. Neah Bay is also sometimes used by vessels in which to ride out rough weather. Clallam Bay is also occasionally used for this purpose.

The currents run through the straits with great velocity, the average being about 3 miles per hour. Off the Race Rocks and Beechy Head it often reaches 6 miles per hour.

There is a peculiar set to the currents which, combined with the prevailing heavy swells and the southwest winds of winter, make it dangerous to get near the northern shore of the straits about the entrance. If a ship near the entrance gets beyond control, she is almost certain, unless rescued, to bring up on the shores of Vancouver Island.

The water in the Straits of Fuca is of great average depth. In some places bottom was not found with a 150-fathom line. The deep water continues close up to shore, as a general thing. The only anchorage on the south shore of the straits near the entrance is in Neah Bay. This anchorage is very imperfect, on account of the bay being open to the swells to the northwest and because of the strong currents through it.

The next anchorage is at Clallam Bay, which is 24 miles inside Cape Flattery. This anchorage is entirely open to the north, but is protected from the south and to a limited degree from the east and west.

The next anchorage is a similarly situated bay, called Freshwater Bay, about 55 miles in from Cape Flattery. The nearest well-protected anchorage to the entrance to the straits is Port Angeles, 65 miles from Flattery.

On account of the conditions above described sailing vessels, as a rule, are towed between Cape Flattery and Port Townsend, a distance of nearly 100 miles. Even with a powerful tug the time occupied by such a tow is about twelve hours. Sudden storms are of frequent occurrence in the vicinity of Cape Flattery, especially in the winter season, and a vessel may leave Port Townsend with the indications favorable for a fair passage clear of the straits only to arrive at the entrance and find a violent storm raging.

The telegraphic communication with Cape Flattery is very frequently broken during the winter, and in that case the condition of the weather at the entrance is not known even when the vessel starts from Port Townsend, as, on account of the high mountain range between Puget Sound and the ocean, the character of the weather on the Sound at any time is apt to be a poor guide as to what it may be on the coast. Under the existing conditions, with no safe harbor within many miles, a vessel once at the entrance of the straits will almost invariably put to sea no matter what the storm may be and take the chances of clearing land rather than take the long tow back. With steam vessels the same is true, only to a lesser extent, as they make the passage to the entrance in less time and can more readily turn back if they desire to. They also run less risk of being blown onto Vancouver Island in a southwest storm, the prevailing direction of winter storms.

Neah Bay in its present condition is not a safe anchorage, as it is entirely exposed to the northwest, and in heavy northwest weather the seas break entirely across it. Tugs frequently anchor there, but sailing vessels very seldom, for a sailing vessel caught in there in a sudden shift of wind to the northwest would be in a very dangerous position.

Under date of January 1, 1895, Capt. Thomas W. Symons, Corps of Engineers, submitted a report of a preliminary examination of Clallam

Bay, Washington, which was published in House Ex. Doc. No. 226, Fifty-third Congress, third session. This report contained a list of wrecks and disasters occurring in the Straits of Fuca and off Cape Flattery and adjacent coast between the years 1874 and 1894 (pp. 7, 8, and 9, said report).

The summary of this table was as follows:

Casualties.	Number.	Remarks.
Vessels stranded in heavy gales and otherwise.	45	Of this number 34 occurred in Straits of Juan de Fuca.
Vessels foundered	6	Of this number 2 occurred in Straits of Juan de Fuca.
Vessels capsized and abandoned	9	All occurred off Cape Flattery.
Vessels leaking and otherwise disabled by storms.	14	Of this number 10 occurred off Cape Flattery.
Vessels in collision	14	Of this number 8 occurred in Straits of Juan de Fuca.
Vessels burned	4	Of this number 2 occurred in Straits of Juan de Fuca.
Vessels missing	2	Outside of Cape Flattery.
Vessels foundered or stranded	14	Along southwest shores of Vancouver Island; exact location not recorded.
Total	108	

The following wrecks and disasters are known to have occurred in the vicinity since those reported by Captain Symons:

Name.	Rig.	Flag.	Date.	Nature of casualty.	Location.	Loss.
Moonlight	Schooner	United States.	Sept., 1894	Sprung a leak	Off Cape Flattery.	Partial.
Melrose	Bark	do	Nov., 1894	do	Straits of Fuca	Do.
Southern Chief	do	do	Dec., 1894	Abandoned at sea in a waterlogged condition; afterwards towed to Port Townsend.	Off Cape Flattery.	Do.
Scottish Dales	Ship	British	do	Partly dismasted	do	Do.
Vancouver	Steamer	United States.	Mar. 6, 1895	Rudder disabled	20 miles from Victoria.	Total.
Mogul	Tug	do	May 12, 1895	Put ashore in distress.	2 miles west of Neah Bay.	Do.
Warrimoo	Steamer	British	Aug., 1895	Stranded	Carmanah Point, Vancouver Island.	Partial.
Strathnevis	do	do	Oct., 1895	Lost propeller	Pacific Ocean	Do.
Wachusett	Ship	United States.	Dec., 1895	Cargo shifted during heavy gale.	Straits of Fuca	Do.
Signal	Steamer	do	Dec. 28, 1895	Swept by seas	do	Do.
Marion	Barkentine.	do	Dec., 1895	Swept by seas and partly filled.	Outside Cape Flattery.	Do.
Janet Cowan	Ship	British	Dec. 31, 1895	Stranded	Near Carmanah Point, Vancouver Island.	Total.
Maybell	Schooner	do	Jan., 1896	Foundered	Outside Cape Flattery.	Do.
Nineveh	Ship	do	Jan. 28, 1896	Dismantled and abandoned.	do	Do.
Kilbrannon	do	do	Feb. 5, 1896	Stranded	Point Wilson	Partial.
Progressist	Steamer	do	July, 1896	Lost propeller	Straits of Fuca	Do.
Canada	Bark	United States.	Oct. 24, 1896	Collision in fog	do	Do.
Puritan	Schooner	do	Nov., 1896	Stranded	Bonilla Point, Vancouver Island.	Total.
Samaria	Ship	do	Apr., 1897	Lost at sea	Pacific Ocean	Do.
Germania	Bark	do	Oct., 1897	Cargo shifted; vessel towed back to Bellingham Bay.	Outside Cape Flattery.	Partial.

REMARKS.

Strathnevis.—Taken in tow by steamer *Miowera* December 18. On December 23 tow-line parted near Cape Flattery during gale. December 24 taken in tow by steamer *Mineola*, and towed to Port Townsend.

Wachusett.—Put into Port Angeles December 22 with a 6-foot list, leaking badly, and with 6 feet of water in hold. Lightened 200 tons of cargo and made temporary repairs.

Marion.—Jettisoned deck load during heavy gale.

Samaria.—Sailed from Seattle March 30. Wreckage of house, boat, and life buoy with name *Samaria* came ashore on Cape Disappointment April 24.

Schooner *Louisa D.* arrived at San Francisco April 27, 1897, and reported that on April 20, when 30 miles southeast of Cape Flattery, passed through a large quantity of wreckage, and picked up two doors and portion of camphor-wood chest.

Steamer *Ella Rohlffs* arrived at Fort Wrangell April 2, 1897, and reported that on March 30, when 110 miles off Cape Flattery, passed through wreckage, evidently of a small schooner.

Wreckage reported by Nicaraguan bark *Dominion*, 80 miles southwest of Cape Flattery, January 5, 1895.

Hull of a large double-decked vessel reported near the entrance to the Straits of Fuca, January 28, 1895.

The ship *Ivanhoe*, given by Captain Symons, Corps of Engineers, as "missing," is now known to have foundered in a gale off Cape Flattery, probably a very short time after passing out.

Steamers *Montserrat* and *Keweenaw* lost off Cape Flattery December, 1894. Both steamers loaded with coal for San Francisco.

From the conditions under which the commerce passing through the Straits of Fuca is carried on, as described above, and the number of wrecks which have occurred, it seems that this commerce does frequently need a harbor of refuge.

Is, then, Neah Bay the best and most suitable place for such a harbor of refuge? As to this there seems to be no doubt. Neah Bay is within 5 miles of the extreme point of Cape Flattery, practically at the very entrance to the straits. There is no harbor of any kind nearer the entrance. The nearest inside is Clallam Bay, which has already been unfavorably reported upon, partly on account of its distance. And there is no possible location for a harbor of refuge within 100 miles south of the entrance; in fact there is no harbor of any sort worth mentioning within that distance. Therefore, if there is to be a harbor of refuge, Neah Bay must be the place.

What will be the cost of constructing a harbor of refuge at Neah Bay? No attempt has been made to make any estimate as to the cost, as sufficient data are not available. In a general way, however, it may be stated that the expense will not be excessive. Neah Bay proper is approximately a mile deep below the general coast line and 2 miles wide. Lying to the northeast of the bay is an island somewhat over half a mile in length. This island lies in such a manner as to partially close the bay to the northeast, so that with the bay proper and the water protected by the island a basin about a mile and a half deep is formed with a narrow opening to the east and an opening about a mile and a half wide to the northwest. A breakwater located so as to protect the bay from the northwest would therefore afford all the protection required. There is no stone in the immediate vicinity which could be used for such a breakwater, but it is believed that ample suitable stone can be found on Puget Sound, so that the cost per ton will be reasonable; and as the length of the breakwater would probably not exceed a mile, the cost, as stated above, should not be excessive.

I am therefore of the opinion that Neah Bay is worthy of improvement "as a harbor of refuge," and that the improvement is justified by the interests of commerce involved.

I inclose herewith a tracing from a Coast and Geodetic Survey chart, showing Neah Bay and its immediate vicinity.

It is estimated that to make the requisite survey and prepare plans and estimates for the improvement will cost $500.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE,
PACIFIC DIVISION,
San Francisco, Cal., November 22, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the opinion of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

V V 13.

SURVEY OF MOUTH OF WILLAPA RIVER AND MAILBOAT SLOUGH, WASHINGTON.

[Printed in House Doc. No. 100, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 2, 1897.

SIR: I have the honor to submit the accompanying report of August 20, 1897, with map,* by Capt. Harry Taylor, Corps of Engineers, of the results of a survey of mouth of Willapa River and Mailboat Slough, Washington, made to comply with provisions of the river and harbor act of June 3, 1896.

The river is obstructed by two bars between South Bend and the mouth, and the plan of improvement proposed by Captain Taylor is to dredge these two bars to a depth of 20 feet at mean lower low water—the width through the lower bar to be 200 feet and through the upper bar 100 feet. He estimates that the work proposed will cost, in round numbers, $80,000.

In submitting his report Captain Taylor states that, in his opinion, the proposed improvement is a worthy one and is justified by the interests of commerce involved. This opinion is concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

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*Not reprinted. Printed in House Doc. No. 100, Fifty-fifth Congress, second session.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., August 20, 1897.

GENERAL: I have the honor to submit the following report of a survey of the mouth of the Willapa River and Mailboat Slough, Washington, made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

Willapa River empties into the Pacific Ocean through Willapa Harbor about 25 miles north of the mouth of the Columbia River. The entrance to Willapa Harbor from the ocean has for many years maintained a depth of over 18 feet at mean lower low water, and at the present time has a depth of about 21 feet at mean lower low water.

The mouth of the Willapa River is considered to be in the harbor about 12 miles in a direct line from the ocean bar. From the ocean bar to this point the depths are ample for any class of vessels, ranging from 27 feet to as much as 70 feet at mean lower low water. Near its mouth the Willapa River is joined by the North River, which flows in a course nearly at right angles to that of the Willapa. Just above the junction of these two streams is a bar having a ruling depth of water over it of about 16 feet at mean lower low water. The bottom of the river at this bar is lumpy and the material forming it appears to be fine hard sand and silt. This bar separates the deep water of Willapa Harbor from the deep water of that part of Willapa River below Mailboat Slough, which is a small cut-off channel, leaving the Willapa River about one-half mile above Southbend, the principal city on this harbor, and joining it again about 1½ miles below the city. Immediately above the lower end or mouth of Mailboat Slough is another bar, having a controlling depth of about 14½ feet at mean lower low water. These two bars have existed with about the same depths which they have to-day since the earliest recorded surveys of this harbor were made, except that the upper bar has scoured away from 2 to 3 feet since 1892, when the Government began the construction of a dike closing the upper end of Mailboat Slough.

The principal businesses of Willapa Harbor are the lumber business and the fish and oyster business. Located at Southbend are three sawmills, whose combined aggregate daily capacity is about 150,000 feet. It is reported that two of these mills are to be rebuilt, with largely increased capacities.

The lumber is mostly shipped to San Francisco in small schooners, as deep-draft vessels are denied charter for cargo from this harbor on account of the two bars above mentioned. It is claimed that were these two bars removed the mills located on this harbor would be able to compete with the mills of Puget Sound, Columbia River, and other deep-water Pacific coast ports in the foreign lumber trade. Whether the lumber business of this harbor would be so extended or not may be questioned, but there can be no question but that the present trade would be materially benefited, as the vessels which now carry the lumber experience delays on account of these bars. One flood tide is required for loaded vessels to cross the two bars. Before the harbor throat (distant about 19 miles from Southbend) is reached the tide is ebbing. As insurance companies prohibit vessels towing to sea on an ebb tide, they are forced to lie at anchor in a rather poor roadstead, called North Cove, for about twenty-four hours. During the winter

southwest storms frequently spring up and vessels may be bar bound from one day to a week or more after leaving Southbend.

I am of the opinion that the most advantageous and economical method of improving these bars is to dredge a channel through them to a depth of 20 feet at mean lower low water. Near the lower shoal mud flats, which are covered at a 2-foot stage of tide, extend about 1¾ miles to the north and about 1 mile to the south. At high tide this forms a wide expanse of water, and for this reason the channel through the lower shoal should not be less than 200 feet wide. The channel through the upper shoal may be reduced to 100 feet in width. The waters of Willapa River carry but little sediment in suspension, its course is short, and for 12 miles above Southbend it is a tidal stream. For these reasons it is believed that a dredged channel would be fairly permanent.

The estimated cost of this improvement is as follows:

Dredging at lower shoal, 250,000 cubic yards, at 20 cents	$50,000
Dredging at upper shoal, 100,000 cubic yards, at 20 cents	20,000
Engineering, contingencies, etc	7,000
Total	77,000

or in round numbers, $80,000.

Forwarded herewith is a tracing, upon which are shown the two shoals and adjacent portions of the river and the location of the proposed dredging.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

V V 14.

SURVEY OF QUILLAYUTE HARBOR AND RIVER, WASHINGTON.

[Printed in House Doc. No. 130, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 4, 1897.

SIR: I have the honor to submit the accompanying copy of report with map,* dated November 5, 1897, by Capt. Harry Taylor, Corps of Engineers, upon the results of a survey of Quillayute Harbor and River, Washington, made to comply with the provisions of the river and harbor act of June 3, 1896.

The plan of improvement submitted provides for the closing of the present river mouth by means of a dike, the reopening of the old mouth, the protection of the sand spit between the existing lagoon and the ocean, and the making of a cut across the sand spit to the south of the lagoon into Quillayute Harbor. The cost of the work is estimated at $20,000.

* Not reprinted. Printed in House Doc. No. 130, Fifty-fifth Congress, second session.

The essential features concerning the plan of improvement presented are referred to in the report.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., November 5, 1897.

GENERAL: I have the honor to submit the following report of a survey of Quillayute Harbor and River, Washington, made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896:

Quillayute Harbor is an inaccessible portion of the State of Washington, being a small rock-bound arm of the Pacific Ocean, 30 miles south of Cape Flattery. The ordinary means of reaching Quillayute Harbor is by boat to Clallam Bay, thence over a rugged mountain trail to a small town on the Quillayute River about 2 miles above its mouth, thence down the river by canoe. At the mouth of the river is a small Indian town, known as "Lapush." In calm weather passengers can be taken from this town by the Indians in a canoe outside in the open ocean to a point just south of Cape Flattery, from whence is a trail which leads over to Neah Bay on the Straits of Fuca, where boats occasionally call.

Quillayute River proper is only about 5 miles in length. It has a number of tributaries, but all of them are shallow and navigable only by canoes. They are, however, suitable for logging during six or eight months of the year. The principal tributaries of the Quillayute River rise in the Olympic Mountains and flow in a generally southwesterly direction, their courses being parallel for the greater part of their length. Two of these tributaries are about 50 miles in length, each is navigable for canoes for about half the distance, and it is reported that logs can be driven down these streams from near their head waters.

The total drainage area of the Quillayute and its tributary rivers is about 650 square miles. The greater part of this is mountainous country covered with a heavy growth of fir and spruce timber. The valleys and river bottoms cover probably 100 square miles, and in addition there are several plains or "prairies" on which there is no timber and the soil of which is extremely fertile. The largest of these, which is locally known as the "Quillayute Prairie," is $4\frac{3}{4}$ miles in length and one-half mile wide and contains about 1,500 acres. The second in importance is Forks Prairie, and contains probably 1,000 acres. The third is known as "Tyee Prairie," and contains about 500 acres. There are several other such prairies of smaller area.

The country is at present sparcely settled, the population being probably 350. A large part of the land, however, has been taken up in homesteads and timber claims, but many of the settlers have left the country during the past two or three years during the prevailing hard times, due to the difficulty of making a living in a region so inaccessible from the markets of the world and the bases of supply.

In addition to the white population there are about 250 Indians of the Quillayute tribe, most of whom live in the village called Lapush, on the ocean beach near the mouth of the river, where this tribe has been settled for a century or more. These Indians subsist almost entirely by fishing, whaling, and sealing; but owing to the great diminution in the number of seals the last-named industry has practically ceased to exist during the last few years.

The greatest drawback to the Quillayute country is the inaccessibility of the region and the difficulty and expense of getting goods in and out. At the present time everything must be brought into the country over the trail from Clallam Bay, on the Straits of Fuca, or by way of Lapush. Most of the merchandise which is brought into the country comes by the way of Clallam Bay. Little is brought by way of Lapush except such supplies as are brought in by the Washington Fur Company, which maintains a post at that point. This company owns its own schooner and brings goods directly to Lapush several times a year, the schooner lying at anchor in the harbor while the goods are brought ashore by Indians in canoes. The cost of bringing goods in by way of Clallam Bay is about $20 per ton for packing from Clallam Bay to Quillayute River, in addition to $5 per ton from Seattle to Clallam Bay. These rates keep the imports down to the lowest limit and practically prohibit any exporting. The white settlers in the country are chiefly engaged in general farming.

If there were any easy means of exporting, it is probable that a sawmill would be established at the mouth of the Quillayute River. There is an abundance of good timber in the country, and a good site for a mill could be found at or near the mouth of the river. There is no doubt that ample inducements would be offered by the settlers to any company offering to build a sawmill in the country, as its establishment would not only enable them to dispose of their timber, but would permit them to obtain supplies from the outside world at considerably lower freight rates.

A map of the Quillayute Harbor and River, which is forwarded herewith, shows that the harbor is well sheltered on the northwest, but open to the southwest, which renders the harbor useless in winter, as the prevailing winds are from that direction. Although the harbor is hemmed in by precipitous cliffs and high rocky islands, it is itself entirely free from rocks. Its prevailing depth is 12 feet at low tide 800 feet from the low-water line of the beach, and the bottom slopes regularly toward the ocean. At the entrance to the bay there is a general depth of 6 to 7 fathoms. The mean range of tide is about 8 feet. The mouth of the river was formerly at the north end of this bay, but about twenty years ago this mouth became closed up and the river broke through a narrow sand spit into the ocean three-fourths of a mile farther north, forming a new mouth, which varies in width according to the seasons of the year and according to the water flowing through it. At the time of the survey it was but little over 40 feet wide.

The bay into which the river now flows is rocky, exposed, and dangerous, and there is a bar just off the mouth of the river. No improvement of this present mouth seems feasible.

The improvement desired by the inhabitants of the Quillayute country is the reopening of the old mouth of the river. The lagoon which formerly formed part of the river is separated from the ocean by a narrow sand spit 350 feet wide at high water and having a maximum elevation of about 12 feet at mean lower low water. This lagoon at the south end has a depth of 4 feet at mean lower low water, as referred to that

datum in the ocean, but the actual depth is about 8 feet, as the surface of the water in the lagoon is 4 feet higher than the ocean when the tide is out, on account of the north end of the lagoon having been choked up with sand to a height of 4 feet above mean lower low water. To reopen the old mouth of the river it would be necessary to close the present mouth by a dike, to protect the sand spit between the existing lagoon and the ocean, and to make a cut across the sand spit to the south of the lagoon into the Quillayute Harbor.

The estimated cost of this improvement is as follows:

Dike of piles, brush, and stone, 1,000 feet, at $5 per foot	$5,000
Protection sill of brush and stone, 4,400 feet, at $2 per foot	8,800
Excavating cut across sand spit	3,200
Removing snags and other obstructions by blasting	1,200
Engineering, superintendence, and contingencies, 10 per cent	1,820
Total	20,020

or, in round numbers, $20,000.

In the summer the river is low and does not carry much water. In the spring and fall, however, the water is high and the current rapid. The fall freshets are due to heavy rains and the spring freshets to the melting of snow in the mountains. The river reaches its greatest height of about 10 feet above the low-water stage during the fall freshets, usually in November. It is probable that if the improvement as outlined above were made during the summer the fall freshets would scour out the channel through the lagoon and across the sand spit into the Quillayute Harbor, as the material at the north end of the lagoon would be readily moved by the current, and the sand spit between the south end of the lagoon and the harbor would be easily scoured away.

The reopening of the old river mouth is the most practicable and feasible scheme of improvement of this river and would probably afford considerable relief to the settlers, but I am not of the opinion that it would accomplish all of the results which are desired or anticipated by them. The outlet of the proposed channel is into the Quillayute Harbor, where it is protected from the northwest winds, but is completely exposed to the southwest winds, which are the prevailing winds during the winter and are the ones blowing during the most violent storms. Heavy seas would break directly into the mouth of the river and would close all but a space barely sufficient to allow the water flowing in the river at the time to flow through. Indications are that the river carries considerable sediment and drift during its higher stages, and with the present outlet of the river closed there would be an excellent opportunity for the deposition of sediment and the collection of drift in the river above the dike. It is probable that the proposed improvement would afford a safe outlet to any logs which might be cut and put into the river, and if a sawmill were erected, it would afford an opportunity to float any sawed timber out on lighters to vessels which might lie at anchor in the outer harbor. It is not probable, however, that a channel would be scoured out and maintained which would permit vessels of any size to enter the river under any but the most favorable conditions of high water and still weather.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

V V 15.

SURVEY OF DESCHUTES RIVER AT ITS ENTRANCE IN OLYMPIA HARBOR, WASHINGTON.

[Printed in House Doc. No. 104, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 2, 1897.

SIR: The river and harbor act of June 3, 1896, provides, in the item of appropriation for improving Olympia Harbor, Washington, that a survey be made of the Deschutes River at its entrance in Olympia Harbor, and the cost of its improvement to be estimated.

The duty of making the survey thus called for was assigned to the charge of Capt. Harry Taylor, Corps of Engineers, and I have now the honor to submit his report, with map,* dated July 27, 1897, upon the subject.

The harbor of Olympia is now being improved by the General Government in accordance with a plan which provides for dredging a channel 250 feet wide and 12 feet deep at the mean of the lower low waters from the vicinity of the Fourth Street Bridge to deep water in Budd Inlet. Provision is also made in the existing project for a turning basin near the inner end of the channel.

Two methods of improvement are suggested in the accompanying report, one by dredging a channel sufficient to accommodate shallow-draft boats, and the other to form a fresh-water harbor south of Fourth street. The former method is estimated to cost $264,000, and, Captain Taylor reports, would facilitate the export of beer and possibly in the future some other manufactures. The latter plan is estimated to cost in excess of $1,000,000, and, Captain Taylor states, might result in stimulating the lumber industry of Olympia. The essential features of both plans are set forth in the report.

In the opinion of Captain Taylor and of the division engineer, Col. Charles R. Suter, Corps of Engineers, neither form of improvement is justified by the interests of commerce, nor is any improvement of the Deschutes River or Olympia Harbor, other than that which is already nearly completed, justified by the interests of commerce involved.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., July 27, 1897.

GENERAL: I have the honor to submit the following report of a survey of the Deschutes River at its entrance in Olympia Harbor, made in compliance with the requirements of the river and harbor act of June 3, 1896.

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* Not reprinted. Printed in House Doc. No. 104, Fifty-fifth Congress, second session.

The item in accordance with which this survey was made is as follows:

Improving Olympia Harbor, Washington: Continuing improvement, $32,000; and that a survey be made of the Deschutes River at its entrance in Olympia Harbor, and the cost of its improvement be estimated.

The Deschutes River rises in the foothills of the Cascade Mountains, and, flowing in a generally northwesterly course, empties into the upper or south end of Budd Inlet at Tumwater, where it meets tide water. Olympia is located on Budd Inlet, about 2 miles north of Tumwater; and the part of Budd Inlet in the vicinity of the city is known as Olympia Harbor.

At Tumwater, just before it meets tide water, the Deschutes River plunges over three falls, having an aggregate height of about 84 feet. The river above these falls is unnavigable. The water power of these falls is partially developed at present, being made use of to furnish the necessary power for an electric-light plant and for the operation of a street railway in the city of Olympia, and for a brewery, ice factory, flour mill, and sawmill located at the falls. The products of all the establishments at Tumwater are consumed in Olympia, except those of the brewery, part of which is shipped to other points on Puget Sound.

The survey was limited to the part of the Deschutes River below the falls, as it was understood that this was the intent of the law.

The improvement to be made and its cost will depend largely upon the object to be attained. If the object is to obtain a channel to the falls, so that the products of the manufactories located there can be shipped directly by water, the most advantageous and economical improvement would be to dredge a channel sufficient to accommodate the ordinary stern-wheel boat common to these waters. The harbor lines of Olympia Harbor have been fixed by the Secretary of War. What is called the Deschutes Waterway extends nearly to the foot of the falls. To dredge this waterway to a depth of 6 feet at extreme low water to the full width of the waterway, from a connection with the present dredged channel in front of Olympia to Tumwater would, it is estimated, cost $264,000.

While this improvement would be proper for the purpose of obtaining a channel to Tumwater, it would, in my opinion, affect the harbor and city of Olympia disadvantageously. The Deschutes River in times of flood carries a large amount of sediment, which is deposited as soon as tide water is met. Previous to last year there had been considerable shoaling in the channel already dredged to the Olympia docks, due to the fact that the river partially emptied into the harbor through the Capitol Waterway. This waterway extended from the southern part of the turning basin, now forming part of the improvement of the harbor, south beyond Fourth street. In 1896 the harbor lines were modified, the Capitol Waterway closed at Fourth street by a bulkhead, and the Deschutes River entirely turned over into the Deschutes Waterway. Running down this waterway is a shallow channel, which the river now follows and deposits its sediment on the side of the harbor away from the part improved. To dredge out the Deschutes Waterway and again turn the river into the improved channel would be to again bring about the conditions which favored filling the channel already improved. In other words, the improvement under consideration would extend the navigable channel of the Deschutes River above Fourth street in Olympia to the disadvantage of the part below it.

Fourth Street Bridge originally contained a draw, which was located across the Capitol Waterway. For some years past one of the city water mains was laid across this draw, from which it may be inferred that there was not much use for the draw. At present there is no draw

in this bridge. The Northern Pacific Railroad also crosses the harbor about half a mile south of Fourth street on a trestle without any draw in it. Should the improvement under consideration be made it would necessitate draw spans in both bridges.

Another form of improvement which I have been informed is desired is to form a fresh-water basin south of Fourth street. It is desired that the bulkhead under the Fourth Street Bridge shall be used as a dam, and a lock be put in the Deschutes Waterway, so as to maintain the level of the water south of Fourth street—a level above high tide. Detailed estimates of the cost of an improvement of this character have not been made, but sufficient data have been obtained to indicate that the cost would be in excess of $1,000,000. Fourth street originally crossed the harbor on a pile trestle.

During the time the improvement of the harbor has been going on the excavated material has been largely deposited under this bridge, until now it is filled solid from the eastern side of the harbor to the Deschutes Waterway and to about extreme high tide. This filling, which consisted of sand and mud, has been retained in place by plank and brush bulkheads, provided principally by the city. While this bulkhead stands, so long as the water pressure is practically the same on the two sides, it is not adapted to serve as a dam. Borings made in the vicinity of this bulkhead indicate that the bottom, to a depth of at least 15 or 20 feet, is of soft sand and mud. The extreme variation of the tide at Olympia is about 21 feet. The construction of a dam to resist the pressure to which it would be subjected would, under the circumstances, be an extremely difficult piece of engineering. I was, however, informed by a prominent city official that this was the improvement desired, and that it was hoped that if it were made a sawmill could be induced to locate on the fresh-water basin thus formed, as it would form a fine storage basin for logs.

I have also understood that it is desired by others to have the fill under Fourth street raised some 3 feet or more to the street grade and protected by stones. This might be of advantage to the street and save the city the expense of occasionally replanking the street, but I am unable to see that it would have any effect upon the harbor.

During the progress of the last contract for dredging the city officials endeavored to have the dredger deposit some of the dredged material along the line of the street so as to raise the fill, but as the city officials and contractors were unable to agree upon the price to be paid it was not done.

Inclosed herewith is the report of my assistant, who made the survey, and a tracing of the harbor.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., August 2, 1897.

Respectfully forwarded.
I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of *Engineers, Division Engineer.*

REPORT OF MR. JOHN ZUG.

SEATTLE, WASH., *July 15, 1897.*

CAPTAIN: I have the honor to submit the following report of an examination and survey of the Deschutes River at its entrance in Olympia Harbor, made under your directions, together with estimates for its improvement:

The Deschutes River rises in the foothills of the Cascade Mountains, and, flowing in a generally northwesterly course, empties into the upper end of Budd Inlet, at Tumwater, where it meets tide water. Here, within a short distance of each other, are three waterfalls, having an aggregate fall of 84 feet. The water power of these falls is partially developed at present, being made use of to furnish the necessary power to operate a street railway and electric-light system for the city of Olympia. The maximum capacity of the middle falls, where the power house is located, is 400 horsepower. The maximum capacity of the three falls when fully developed will reach 4,000 horsepower. The chief industries located here are a brewery, ice factory, flour mill, and sawmill. The products of all these establishments are used for local consumption, except the first named, which, in addition to supplying the city of Olympia, ships a considerable portion of its output to various points on Puget Sound.

The entrance of the Deschutes River is considered to be that portion of Budd Inlet between Fourth street, Olympia, and Tumwater, which is about 2 miles in length. The survey, however, covered the entire harbor of Olympia. The survey was made by taking approximately parallel lines of soundings across the harbor and locating the ends of the lines by means of sextant observations to establish signals on shore. Where the lines were very long, intermediate observations were taken to insure accuracy of location. These lines were taken generally about 200 feet apart and the soundings along each line at intervals of about 50 feet. The same plane of reference used in previous surveys of Olympia Harbor was adopted, and a new tide gauge, with its zero set exactly at the north end of Percival's Dock at Olympia.

I transmit herewith a map showing the present condition of the Deschutes River entrance and the harbor of Olympia. A larger map has also been prepared, which shows the results of the survey in greater detail. Soundings are expressed in feet, and indicate the depth at extreme low water. Plus soundings indicate elevations above the established datum. It should be observed that "extreme low water" is about 2 feet below "mean lower low water." The depths, therefore, if referred to the latter plane, would be about 2 feet greater.

A series of borings was made at the north end of the Deschutes River entrance to determine the character of the bottom. An iron pipe three-quarters of an inch in diameter and about 25 feet long, having a sharp steel point, was used in making these borings. In most cases no difficulty was experienced in penetrating from 15 to 20 feet, as the material was found to be very soft. That on top is composed of sand, mud, and shells, and it may be safely assumed that the material is of similar character for a depth of 12 feet below mean lower low water throughout the Deschutes River entrance, except at the extreme south end, where there is some rock.

Under the approved project for the improvement of Olympia Harbor a channel 250 feet in width and 12 feet deep at mean lower low water is provided for, with a basin 1,600 feet long and 250 to 500 feet wide at the inner or south end. Work has been done on this project since 1893, and the channel and basin have been excavated to the necessary width, but the full depth has not yet been made except in the basin. About 125,000 yards of material remain to be removed from the channel to complete this project.

The project proposed for the improvement of the Deschutes River entrance consists of dredging a channel 300 feet in width and 6 feet deep at mean lower low water, the location to conform to the established lines of the Deschutes Waterway, as shown on map. This channel will connect with the basin already excavated in Olympia Harbor under the approved project of September 19, 1891, and will extend to the head of Budd Inlet, at Tumwater. This project will require the excavation of about 1,500,000 cubic yards of material, which, at an estimated price of 16 cents per yard, will cost $240,000. This estimate is based on the assumption that the work would be done by hydraulic dredges, and no estimate for bulkheading is included.

The plan which has been suggested, of constructing a fresh-water basin in this locality and providing locks and other necessary works, would be very costly. No detailed estimate of the cost has been made.

Very respectfully, your obedient servant, JOHN ZUG.

Capt. HARRY TAYLOR,
Corps of Engineers, U. S. A.

V V 16.

SURVEY OF MOUTH OF PUYALLUP RIVER, WASHINGTON.

[Printed in House Doc. No. 345, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., March 9, 1898.

SIR: I have the honor to submit the accompanying report of February 16, 1898, with map,* by Capt. Harry Taylor, Corps of Engineers, of the results of a survey of mouth of the Puyallup River, Washington, made to comply with the requirements of the river and harbor act of June 3, 1896.

One improvement desired appears to have for its object the control of the flood waters to prevent overflow of adjacent land, and another the dredging of two waterways deep enough to accommodate ocean-going vessels, one to be called the Puyallup Waterway, the other the City or West Waterway, at Tacoma, Wash.

Captain Taylor presents a project for deepening the Puyallup Waterway to 25 feet at low water throughout its entire length and width by the removal of 3,241,400 cubic yards of material, at a cost, including bulkheading, engineering, etc., estimated in round numbers to be $570,000. In his opinion the land-reclamation project should not be undertaken by the Government as part of river and harbor improvements, and no estimate is presented for the City Waterway for the reason that it is not part of the mouth of the Puyallup River at the present time.

In his letter transmitting this report Captain Taylor states that in his opinion the proposed improvement is not a worthy one and is not justified by the interests of commerce involved. His views are concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers.

Very respectfully, your obedient servant,

A. MACKENZIE,
Acting Chief of Engineers.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., February 16, 1898.

GENERAL: I have the honor to submit the following report of a survey of the "mouth of the Puyallup River, Washington," made in compliance with the requirements of the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The Puyallup River is a stream about 50 miles in length, having its source on the west slope of Mount Rainier, and emptying into Puget Sound near the city of Tacoma.

The Puyallup and its several forks drain an area estimated at 450 square miles. About 10 miles from its mouth it is joined by the Stuck River, which is one of the outlets of the White River, the main

*Not reprinted. Printed in House Doc. No. 345, Fifty-fifth Congress, second session.

part of which drains into the Duwamish. At low water the Stuck River is a small stream, but at high water it is said that it takes about one-third of the water of the White River from the Duwamish into the Puyallup. The White River drains about the same area as the Puyallup, and as one-third of the flood water of the White River finds its way into the Puyallup through the Stuck River it makes the aggregate area drained by the Puyallup and all of its tributaries equivalent to about 600 square miles.

At its source the Puyallup consists of several forks and creeks. For the last 14 miles of its length its waters are confined to one channel, the average width of which is about 150 feet. To within about 7 miles of its mouth the Puyallup River is simply a mountain torrent, carrying at low water a comparatively small volume of water. Its fall is rapid, its current swift, and its channel too shallow for navigation. For the last 7 miles of its length its fall is about 3 feet to the mile, its current is swift, its shoals changeable, and its bends tortuous, all of which tend to make navigation for any kind of craft slow, tedious, and hazardous. For the last 4 miles of its length the river is affected by the tide. Below its junction with the Stuck River it winds through an alluvial bottom land, timbered in places with vine maple, cottonwood, and alder. Its concave banks are perpendicular and show marked signs of erosion. As the banks wear away, the trees growing upon them fall into the river and form obstructions which interfere with the free flow of the water until such time as they are driven to the sound or become embedded in the bottom of the river.

During freshets the water carries in suspension a large amount of sediment, which is dropped when the tide water is met. Around the mouth of the river are extensive tide flats and marsh lands which have been built up by the sediment brought down by the river and deposited in the quiet water at its mouth. Immediately outside the tide flats the water increases very rapidly in depth.

Originally the river found its way into Puget Sound through two or more main outlets or mouths. Several years ago the Tacoma Land Company constructed a dam at the point where the river divided and thereby turned the entire water of the river through the east channel, the present mouth of the river. Since the dam was first built it has been reenforced by a bulkhead or fill of slabs and other waste lumber, until it is now somewhat over 500 feet in width. It was built to prevent the sediment of the river filling up the channel then being dredged by private enterprise along the Tacoma water front.

In 1891 complaint was made in regard to this dam. An official investigation was made by Capt. Thomas W. Symons, Corps of Engineers. He reported that its construction was beneficial to the interests of navigation, and recommended that its location and construction be officially approved.

As I was uncertain what improvement was contemplated as the result of this survey, I instructed my assistant during the survey to ascertain as fully as possible the views of those who would probably be interested in the improvement as to what improvement was desired. Previous to that time I had also made a number of inquiries, and the results of those investigations are as follows:

It is generally admitted that the Puyallup River is a useless stream as far as commerce is concerned, as there is no commerce upon it at the present time, no prospect of any, and no reason why there should be any. At flood time, however, it is reported to be a very troublesome stream, overflowing the lands along its banks, and the most general

desire seems to be such improvement as will relieve these lands from overflow. The lower part of the river flows through the Puyallup Indian Reservation. In fact, the entire course of the Puyallup River, except such parts of it as may be termed a "mountain torrent," are within the limits of this reservation.

The Indian commissioner, Mr. C. A. Snowden, desires such improvement to be made as will prevent inundation of the reservation lands. He states that he desires any improvement which will prevent such overflow, and suggested that the outlet of the river be deepened or that its course be changed to a direct one at some point above its mouth.

Mr. Frank C. Ross, who is interested in property at the mouth of the river, states that since the closing of the west channel his interests have suffered considerably by drift and flood water, and he desires that the course of the river be changed at a point near the city of Puyallup, to follow a sink at the foot of the bluff which flanks the Puyallup Valley on its northeasterly side. This sink joins Hylebos Creek where that stream joins the bottom land and becomes a tidal slough. He states that the soil along this sink is a deep, rich, alluvial deposit, and thinks that if a comparatively small ditch is excavated a distance of about 4 miles that a start would be made carrying the flood waters of the Puyallup River off, and in the course of two or three years the floods in the Puyallup River would cut such a channel as to take the entire river into Puget Sound by this course. He estimates that this improvement can be made for $20,000 outside of the necessary right of way and release from damages.

As a land-reclamation scheme this seems a very good project, in fact much the best suggested; but I do not see that it can be considered as the duty of the Government to undertake such a scheme as part of the river and harbor improvements.

The St. Paul and Tacoma Lumber Company, which has its mill and wharf near the mouth of the river, is one of the large lumber exporters on Puget Sound. One of the members of this firm was consulted and expressed himself as desirous of having the flood waters of the Puyallup controlled in some way. He described the stream as a regular cataract where it joined tide water. He desires to have the course of the river changed to a more direct one at some favorable point near its mouth or have the river widened at a point near the head of old west channel to conform with the proposed State harbor line.

Mr. I. W. Anderson, manager Tacoma Land Company, desires the dredging of two waterways deep enough to accommodate ocean-going vessels, one of these to be called the Puyallup waterway, the other the city or west waterway.

As the city waterway is not part of the mouth of the Puyallup River at the present time, no estimate is given for its improvement. It is estimated, however, that the Puyallup waterway could be deepened throughout its entire length and width to 25 feet at low water by the removal of 3,241,400 cubic yards of material. The cost of this is estimated to be:

3,241,400 cubic yards, at 16 cents	$518,624.00
Bulkheading, engineering, etc., 10 per cent	51,862.40
Total	570,486.40

Or in round numbers, $570,000.

As nearly as I can judge from the wording of the item in accordance with which this survey was made, this seems to be the nearest to the intent of the law of any of the improvements suggested or desired.

It therefore appears that, aside from the dredging of the Puyallup waterway, the only improvement of the Puyallup River desired is simply and solely for the prevention of overflows on the lands of the Puyallup Indian Reservation, and that the interests of commerce are not affected in the slightest degree by any improvement of the river proper. The improvement of the Puyallup waterway would directly benefit only its immediate surroundings. Indirectly it would benefit the city of Tacoma to a certain degree. On account of the sudden increase of depth along the Tacoma water front the available room for building wharves is very limited. Outside the low-water line the depth increases rapidly up to 200 feet or more, so that it is difficult for ships to even find anchorage ground. The wharves of Tacoma are strung along a narrow strip of land at the foot of steep bluffs on the west side of the harbor. This land is principally tide land which has been filled above high tide with material obtained by dredging along the front of the wharves or by hydraulicking down the steep bluffs back of it.

The deepening of the Puyallup waterway would give additional room for building wharves; but in my opinion this is not the proper waterway to deepen for the greatest benefit to the commerce of Tacoma. It will be noticed that two waterways are shown upon the map herewith, upon which the outer harbor line of the harbor of Tacoma is shown. The line shown full is that recommended by Capt. W. L. Fisk, Corps of Engineers, under date of March 7, 1896, for adoption by the War Department, in compliance with an indorsement by the Chief of Engineers, dated January 15, 1896. The records of this office do not show what action, if any, has been taken on this matter. The line shown broken extending the city or west waterway farther south than shown by the full line is the line established by the State land commission.

The estimate given for deepening the Puyallup waterway is for deepening it its full width to a depth of 25 feet at low water, for the reason that if any improvement is undertaken it should be with this end in view. Practically no advantage would be derived from an improvement which stopped with less water, as less depth would not accommodate ocean-going craft, and there is no reason for its improvement for the benefit of any other class of vessels.

The sediment of the river will be deposited in any channel which may be dredged in this waterway, and a considerable sum must be spent annually for its maintenance. The deposition of the sediment would in itself be ample reason why a shallow channel should not be dredged, as it would be practically filled up after two or three floods.

As bearing on this subject, the following extracts from letters received by Capt. T. W. Symons, Corps of Engineers, in 1891, in regard to the closing of the west channel, are quoted:

[Extract from letter from Mr. Wm. F. Prosser, chairman harbor line commission.]

We found that, certain works and dredging operations for the improvement of Tacoma Harbor having been undertaken by the Tacoma Land Company, it was found that owing to the large amount of silt brought down by a branch of the Puyallup River, which flowed into the channel being dredged, that the same was being rapidly filled up and the dredging operations rendered practically nugatory. To prevent this damage, said channel was closed by a pile and earth dam at the bifurcation of the river, and the waters of the river compelled to flow through another channel and empty into Commencement Bay at a point where it is claimed the deposition of silt produces no serious complications.

This commission has approved the dredging operations mentioned and approved the general proposition to exclude the Payallup River from said dredged channel.

[Extract from letter from Mr. Isaac W. Anderson, general manager Tacoma Land Company.]

That before the commencement by this company of its improvements at the head of said bay the Payallup River had its course through three channels, one of said channels being south of lot 2 of said section 3, the second of said channels being east of lot 2 and between lots 1 and 2 of said section 3, which last-mentioned channel was again divided and took its course south of lot 5 of said section 3.

That the original channel of said river was that flowing east of lot 2 and between lots 1 and 2 of said section 3.

That the channel of said river flowing south of said lot 2 was shallow, and from the easterly end of lot 2 to the westerly end of lot 8 of section 4 was filled with snags, stumps, and sand, and was not navigable for any purpose, except possibly that of a canoe, and the sand and mud was washed down the said channel and deposited between the mainland—that is, the land of the Judson donation land claim and lot 8 of section 4—and from there out toward deep water. This sediment has been deposited so rapidly that the bay has been noticeably filled in within the past few years.

That at times of low tide it was impossible for vessels of any draft to reach higher than a few hundred feet above the point marked on said map "R. R. Wharf."

That north of section 4 and in front of section 33 the mud flats lying in said bay were bare at low tide and there was not sufficient depth of water north of section 4 to float a small canoe. That the water bordering on section 32 was extremely deep, as shown by the said map.

That when the Northern Pacific Railroad Company located its terminus here the land company conceived the idea of improving that part of the water front lying in front of section 33 and section 4 by dredging a channel from deep water for the purpose of enabling vessels to get as far south as possible, and to construct between the channels and the mainland suitable docks and wharves. That in order to accomplish this purpose, and with the consent, agreement, and approval of the St. Paul and Tacoma Lumber Company, the owner of lot 2 in section 3, and the Commencement Bay Land and Improvement Company, the owner of lot 1 in said section, it caused to be constructed two dams, one to extend from the southerly end of said lot to the northerly border of lot 3, thereby closing the south channel of said river; another to be constructed from the southerly end of lot 5 to the northerly border of lot 2 in said section, thereby closing the middle channel of said river and causing all of the water of said river to flow through what is known as the easterly or original channel of said river.

The construction of these dams was for the purpose of improving all of the land lying at the mouth of the said river by causing the water thereof to flow through its original channel, and also for the purpose of stopping the débris and sediment from being carried through the southerly channel and deposited between the center of section 4 and the mainland or between the center of section 4 and deep water. That because of the washing and depositing of débris and sediment it would have been impossible, without the closing of the south branch of said river, to have made a channel to extend from deep water in front of section 33 and section 4 bordering upon the mainland.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., February 26, 1898.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

V V 17.

SURVEY OF DUWAMISH RIVER AND ITS TRIBUTARIES, WASHINGTON.

[Printed in House Doc. No. 395, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., March 29, 1898.

SIR: I have the honor to submit the accompanying copy of report dated March 5, 1898, with map,* by Capt. Harry Taylor, Corps of Engineers, giving the results of a survey of Duwamish River and its tributaries, Washington, made to comply with the provisions of the river and harbor act of June 3, 1896.

The improvement of the Duwamish River is carried on from time to time under an appropriation provided by Congress for improving Puget Sound and its tributary waters, the operations consisting of the removal of snags, logs, trees, and other obstructions to navigation. The stream is formed by the junction of the Black and White rivers, and there is at present no navigation on any of the rivers of the Duwamish system.

Captain Taylor states that any demand that there may be for the improvement of this river does not originate in a desire to increase its navigable capacity, nor to improve its navigability, but in a desire to have the bottom lands along its course protected from overflow; but the conditions surrounding the Duwamish River make the problem of protecting these bottom lands from overflow an exceedingly difficult one to solve at an expense that would not be far greater than would be warranted by the present value of the lands concerned, and, in the opinion of Captain Taylor, the only possible way of affording such protection is by a complete and thorough system of dikes, but, for the reasons stated in the report, it does not appear that such work should be undertaken by the General Government.

In forwarding the report to this office the local officer expressed the opinion that the interests of the commerce involved do not justify any improvement of the Duwamish River at the present time other than a small amount of snagging, which can be done, whenever navigation so requires it, with the funds appropriated for improving Puget Sound and its tributary waters, and these views were concurred in by the division engineer, Col. Charles R. Suter, Corps of Engineers.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., March 5, 1898.

GENERAL: I have the honor to submit the following report of a survey of the "Duwamish River and its tributaries, Washington," made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

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*Not reprinted. Printed in House Doc. No. 395, Fifty-fifth Congress, second session.

The Duwamish River is a stream 16 miles long, formed by the junction of the Black and White rivers, emptying into Duwamish, or Elliott, Bay, one of the indentations on the eastern shore of Puget Sound. The city of Seattle is located on the eastern shore of the bay, about 2 miles from the mouth of the river.

In former years, before the advent of the railroads which now traverse the valleys of the Duwamish and its tributaries, the Duwamish and its principal tributary, the White River, were regularly navigated, and small boats have occasionally been taken over the Black River to and from Lake Washington. As it was presumed that this survey was directed in the interests of navigation, it was limited to those tributaries of the Duwamish which had once been navigated and which could again be navigated should occasion demand it. A full description of all the principal tributaries of the Duwamish is given in the report of my assistant, Mr. R. H. Ober, who was in charge of the survey. His report, which is herewith, also contains many interesting details in regard to the river and its immediate surroundings.

The tributaries of the Duwamish have their sources in the Cascade Mountains, and in their upper parts are all mountain torrents, flowing over rough, rocky bottoms with great velocity. They are all subject to regular annual freshets in the spring and summer, due to the melting of the snow around their sources, and to irregular freshets during the remainder of the year, due to rains and "Chinook" winds. Sudden and very marked rises of the Duwamish River are thus of common occurrence.

The lower part of the White River, the Black River, and the Duwamish River flow through an alluvial bottom land but slightly raised above the river bed, and thus subject to overflow whenever there is a flood in the river. The rivers in this part of their courses have a very gentle slope, comparatively narrow width, and are excessively tortuous.

At the mouth the Duwamish spreads out over extensive tide flats which have been built up by the sediment brought down by the river and deposited in the slack water at its mouth, and which now rise to 5 feet or more above the low-water level of Elliott Bay. No marked channel exists across these flats, but the river finds its way to deep water through shallow and changeable depressions only slightly below the general level.

There is no navigation on any of the rivers of the Duwamish system at the present time, as it is impossible for a boat to make expenses on account of the better transportation facilities afforded by the railroads and the consequent lack of business for a boat. About two years ago a small boat made a few trips up the Duwamish River, but gave up the attempt to secure business after about a week's effort. Since that time there has been no attempt at navigation.

As far as the condition of the river is concerned, it may be said to be fully as good for navigation as it was in former years when it was regularly navigated. There are a few snags in the river, but these could be taken out in a week's time by the snag boat which is provided for that purpose, and they would be if there were any navigation to demand it. Aside from this slight amount of work there does not appear to be anything to do in the interests of navigation.

Any demand that there may be for the improvement of this river does not originate in a desire to increase its navigable capacity nor to improve its navigability, but in a desire to have the bottom lands along its course protected from overflow.

The conditions which surround this river make the problem of pro-

tecting the bottom land from overflow an exceedingly difficult one to solve at an expense which will not be far greater than the present value of the lands concerned would warrant.

It seems to be the general impression that a channel dredged through the tide flats at the mouth of the river would afford a freer outlet for the flood water of the river and would materially reduce the height of the floods throughout the valley. I can not agree with this view.

The greatest rise noted was in the White River near the town of Kent, about 30 miles by river from the mouth of the Duwamish. Above Kent there is a sharp fall in the bed of the river, causing a flood to run off rapidly. Near Kent the slope of the river changes abruptly to a very gentle one, and the flood waters striking this gentle slope naturally rise to a greater height than they do either above or below this point. The average slope of the water surface at low water from Kent to Elliott Bay is but a very little over 1 foot to the mile, and the slope is very uniform throughout the entire distance. With such a gentle slope extending for 30 miles over a comparatively narrow, shallow, and extremely tortuous stream, a large rise is a necessary consequence of suddenly pouring a large volume of water into the upper end of the stretch.

Throughout the entire distance the width and depth, as well as the slope, are remarkably uniform, and there is no place in the entire distance where there is any special obstruction which could be removed and afford much relief. The few snags there are insignificant in the effect they have upon the flood waters.

The whole trouble is due to the fact that at no point in the stretch does the channel have sufficient cross section to carry off the floods under the conditions which exist.

At the head of Edwards Island, just inside the tide flats spoken of, the flood level of the river was found by accurate levels to be but two-tenths of a foot above the high-tide level of Elliott Bay at the foot of Madison street, Seattle, which is far enough away from the mouth of the river to be removed from any possible influence of the river floods.

The distance from the head of Edwards Island to the nearest deep water in Elliott Bay is approximately 2½ miles. If, therefore, a channel of sufficient size were dredged for 2½ miles through tide flats whose average level is about five feet above low tide, it would be possible to lower the flood level at this point two-tenths of a foot. During the time the tide was low the water in the river would also fall to a certain extent for some distance up the river, but with the return of the tide the river would again rise. In other words, the only practical effect of any amount of dredging would be to extend the influence of the tide for a short distance, and make tidal a portion of the river near the mouth which is not so at the present time. Moreover, to maintain such a channel, even were it dredged, constant work would be required. A small sample of water taken from near the surface of the river during the survey was found to contain about one part, by weight, of sediment to 1,085 parts of water. This is a very large proportion of solid matter to be carried in suspension, and this of course is dropped as soon as the velocity of flow is checked by the tide water.

In my opinion, the only possible way to protect this valley from overflow is by a complete and thorough system of dikes. Some attempts at dike construction have been made, but they have been isolated, and no system has been followed. In some places dikes were found unconnected to high ground, so that the water was free to run around either

end, and they were generally too low and too near the bank of the river, thus preventing any material increase of cross section of the river except by an abnormal rise.

On account of the extremely tortuous course of the river and the comparatively narrow valley through which it flows, the expense per acre of the land benefited by properly diking the river will be large, but I see no other way to reclaim the present waste land or protect the present improved land from overflow, and, as a dike built along any particular stretch of the river would benefit only a few individuals, it does not appear to me to be a proper undertaking for the General Government.

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. R. H. OBER, SURVEYOR.

SEATTLE, WASH., *January 21, 1898.*

CAPTAIN: I have the honor to submit the following report of a survey of the Duwamish River and its tributaries. The survey was commenced November 4, 1897, and completed December 22, 1897, and included Black River, from Lake Washington to the Duwamish; Cedar River from the Columbia and Puget Sound Railroad Bridge at Renton, to its mouth; White River from the head of navigation at the Northern Pacific Railroad Bridge, 1¼ miles south of Kent, to the Duwamish, and of the Duwamish River to deep water in Duwamish, or Elliott, Bay.

The Duwamish River is a stream 16 miles long, formed by the junction of Black and White rivers, emptying into Duwamish, or Elliott, Bay, one of the indentations on the eastern shore of Puget Sound. The city of Seattle is located on the eastern shore of the bay, about 2 miles from the mouth of the river.

White River, the principal feeder of the Duwamish, heads on the eastern slopes of Mount Rainier in latitude 46° 51′ N., longitude 121° 46′ W., at the foot of a glacier. It skirts the base of the mountain, receiving the waters of several glacial streams for about 6 miles, then pursues a general course of N. 20° W. for about 17 miles to its confluence with Greenwater River, the principal tributary of the upper White River. This portion of White River is characterized by an excessive width, in many places exceeding 800 feet, great fall, and velocity of current over a rough bowlder bed. The water is milky white in color.

Greenwater River, so called from the clear green tint of the water, heads in a small lake lying near the summit of Natchez Pass, in the main range of the Cascades. The old military road, built in 1852, crossed the mountains over this pass and followed the valley of Greenwater and White rivers to the Puget Sound country.

From Greenwater the general course of White River for 19 miles is westerly, then northwesterly 23 miles to its confluence with Green River, its principal tributary. The largest feeders of White River, between Greenwater and Green rivers, are Clearwater Creek, rising on the northern slopes of Mount Rainier, and Boise Creek, draining a portion of the country between White and Green rivers. The average width of White River for this distance is from 150 to 200 feet, with considerable fall over rough bowlder and cobblestone bottom. The total drainage area of White River and all its tributaries above Green River is 477 square miles.

Green River, deriving its name from the color of the water, heads in the Cascade Range at Stampede Pass, in latitude 47° 15′ N., longitude 121° 20′ W., and pursues a general course of N. 85° W. a distance of about 60 miles to its junction with White River. This, like the Upper White River, is torrential in character and flows through a narrow valley with steep slopes on each side. With all its tributaries it drains an area of 399 square miles. The Northern Pacific Railroad, from Puyallup east, passes up the valley of the Puyallup River and of South Prairie Creek, then crosses the rolling country between that and White River. It crosses White River at a point about 13 miles in a straight line from the junction of White and Green rivers, then skirts the base of the foothills on the east, pursuing a general course of N. 40° E. to the valley of Green River, which it enters at a point about 15 miles in a straight line above its mouth. It then passes up the valley and crosses the Cascade Range at Stampede Pass, at the head waters of Green River.

Stuck River separates from White River about 3 miles in a straight line above the junction of White and Green rivers. This is a stream of small cross section at low water, but with considerable fall and consequent great velocity of current. The fall for the first 3 miles is about 25 feet to the mile. It pursues a course of about S. 65° W. for the first 3 miles, skirting the base of a ridge of about 200 feet in height lying on the east and southeast, then swings to the south and runs in a general course of about S. 20° W. to its junction with the Puyallup River. The length of the river is about 9 miles. The last 4 miles has but little fall. The width of the river between the high-water lines is about 400 feet. In places it reaches a width of 600 feet. The width of the stream at low water averages about 80 feet. The river for the first 3 miles is choked with log jams, and flows through a heavily wooded country which is but little settled. The lower part of the river flows through a level and very fertile valley which is thickly settled. The discharge at the average low-water stage is about 40,000 cubic feet per minute. From one-fourth to one-third of the total volume of White River, at low water, passes down Stuck River. At high water probably one half goes down Stuck River. The rise at the head is about 5 feet. At the Northern Pacific Railroad Bridge, about 3 miles below, it is about 7 feet.

From settlers who have lived near by for the last fifteen years and from the Indians on the Muckleshoot Indian Reservation at the head of the river, I learn that Stuck River was formerly but little more than a brook which one could step across at low water. It pursued the same general course as it does now, forming a succession of sloughs with slight depth. Since then it has excavated for itself the present channel, the bottom of which is from 8 to 16 feet below the level of the valley. It is constantly jamming up with logs and drift, which back up the water and force it to cut a new channel around the obstruction. The river is crossed by the Northern Pacific Railroad Bridge at a point about 3 miles below its head. This bridge is 210 feet long, consisting of three spans of 60 feet each and one of 30 feet, plate girders of steel on first-class masonry piers.

From Green River, White River flows in a northerly course through a wide and fertile valley for about 5 miles, then turns abruptly to the west, a distance of about 1¼ miles to the point where the Northern Pacific Railroad, from Seattle to Puyallup, crosses the river. This point is the head of navigation and is the initial point of the present survey. Thence the river flows at first northwesterly, then northerly, then northeasterly, a total distance of 14.5 miles in a tortuous course to its confluence with Black River, the union of the two forming the Duwamish. The distance in a straight line is 7.83 miles. The lower 3 miles is affected very slightly by the tides at times of extreme low water in the river.

White River, from the Northern Pacific Railroad Bridge to the Duwamish, flows through a bottom land having a width of from 2 to 3 miles. The soil is a deep, rich, alluvial deposit. The greater portion of the land has been cleared and put under cultivation. The remainder is swampy, and is covered with a dense growth of alder, maple, and cottonwood. Successive freshets by depositing the sediment, which is carried by the current in discontinuous suspension, have, in the course of ages, built up the banks of the river and the area adjacent to a considerable height above the general level of the valley. This superelevation varies from 3 to 8 feet. The low ground is generally found near the foot of the flanking hills, which rise to a height of from 200 to 400 feet above the valley. These are surmounted by a rolling upland which is but sparingly cultivated.

The Duwamish River proper, although 16 miles in length, as measured along its sinuosities, extends over a distance of but 7.81 miles, measured in a straight line. It flows through a bottom land, having a width of from 1 to 2 miles, most of which is subject to overflow during freshets. The portion of the valley nearest the river is usually higher than that near the foot of the flanking hills, but the difference in elevation is but slight as compared with that along White River. The area of cultivated land is less in proportion to the area of the valley, and the area of the waste and swampy land is greater.

The entire length of the Duwamish is tidal at stages of ordinary low water. At high water in the river the tides do not affect the level of the river at the head. At seasons of low water the variation at that point is about 1 foot.

At its mouth the Duwamish is divided into two channels by a large island, known as Edwards Island. The channel on the right goes entirely bare at mean lower low water, and is obstructed by the trestle of the old Commercial Street Electric Railroad. That on the left is very shoal, carrying but about 1 foot of water at extreme low tides at low-water stage in the river, and spills out over mud flats extending for a distance of 2½ miles to deep water. The Seattle Terminal and Elevator Company's trestle extends across the lower edge of the tide flats in nearly an east and west course. The drawspan on this trestle was formerly located in the line of the slight depression in the flats extending from the mouth of the west channel of the Duwamish to deep water, but was moved 3,200 feet to the eastward about two years ago, to conform with the plans of the Seattle and Lake Washington Waterway Company. This com-

pany has dredged a channel from deep water to a point about 600 feet south of the trestle. Boats entering the Duwamish after passing through the draw are obliged to cross the slightly elevated portion of the mud flats immediately south of the trestle, a distance of about one-half mile, to the old channel. Boats drawing 5 feet can not cross this portion of the flats at stages below half tide.

There was formerly a third channel of the Duwamish, beginning about 2,000 feet above the upper end of Edwards Island and joining the left or west channel at the head of the island, but that is now choked by snags and sand collected by a system of boom piles driven at the head of the channel.

The Northern Pacific Railroad from Puyallup to Seattle crosses White River 16 miles above its mouth and follows the general course of the valley at the base of the hills on the east. It crosses Black River about 200 feet above its mouth and joins the Columbia and Puget Sound Railroad at Black River Junction, thence following the roadbed of the latter to Seattle, skirting the base of the ridge on the east of the river. On the line of the Northern Pacific Railroad are located Kent and Slaughter, now named Auburn. Kent, at the head of navigation on White River, 16 miles from Seattle, has a population of 850, according to the census of 1890. Slaughter, near the junction of White and Green rivers, and 21 miles from Seattle, has a population of 740. The settlers in the valley are principally engaged in farming, dairying, and hop raising. There is a sawmill at Kent with capacity of 40,000 feet B. M. per day of nine hours.

The railroad gives ample facilities for the transportation of the products of the valley to market. A network of wagon roads gives communication with all parts of the valley under cultivation. White River is crossed by two wagon bridges and two ferries.

The portion of the valley on the west side of the upper Duwamish is but little settled. There is no wagon road on this side for a distance of 5 miles below Black River. At this point the main road from Tacoma to Seattle descends from the high ridge on the west to the river valley, and follows the foot of the hills to River Park. It crosses the Duwamish about one-half mile above River Park and follows the base of the hills on the east to Seattle. The road which follows the right bank of the river for the entire distance from Kent joins the main road at Georgetown.

South Park, or River Park, is a town of probably 400 inhabitants, situated on the left bank of the Duwamish 6 miles above its mouth. It is the terminus of the Grant Street Electric Railroad, 5 miles from Seattle. Georgetown, or Duwamish, is a suburb of Seattle, on the right bank of the Duwamish 3½ miles above its mouth. It is on the line of the Grant Street Electric Railroad 4 miles from Seattle.

Black River, a shoal and narrow stream 3.65 miles long, drains the basins of lake Washington and Sammamish and receives the waters of Cedar River at a point 3.70 feet below the foot of Lake Washington. Lake Sammamish has an area of 8 square miles and a length of 7 miles, with an average width of a little over 1 mile, and a depth of 50 feet. The area of its drainage basin is 211 square miles. The surplus waters are discharged into Lake Washington through the Sammamish River, which is a stream of small velocity, averaging about 50 feet in width, with a depth generally of from 6 to 8 feet. The length of this river is about 17 miles.

Lake Washington has a length of 19 miles, an area of 38.9 square miles, an average width of 2 miles, and a maximum depth of 198 feet. The area of the drainage basin of the lake is 182 square miles. The elevation of the low-water plane is 20.1 feet above the Puget Sound datum plane. It has a range of 3.3 feet between the low-water plane and the highest flood marks observed. The greatest rise reported during former years was 7 feet.

The shore of the lake is generally abrupt. The lake is surrounded by low hills rising to an elevation of from 300 to 500 feet above the lake. These are surmounted by a heavily rolling plateau, which is but thinly settled. The products of the country adjacent to the lake are shipped to market over the Seattle, Lake Shore and Eastern Railroad, which skirts the northern and northwestern shores of the lake, and by the small steamboats which ply upon the lake. The produce from the farms along the western shore is shipped over the street car lines and by wagon road.

Cedar River heads on the Cascade Range, in latitude 47° 22′ N., longitude 121° 30′ W. It pursues a general course of N. 80° W. to its junction with Black River, a distance of about 55 miles. This is a narrow and shallow stream, carrying but little water except during flood seasons.

The low-water discharge of Cedar River at Maple Valley, about 15 miles above its mouth, was, in 1895, about 8,500 cubic feet per minute. In 1897 it was 18,000 cubic feet per minute. The season of lowest water is during September and October. The maximum discharge usually is in November, when it has reached 200,000 cubic feet per minute. The normal flow is about 50,000 cubic feet per minute. At low-water stages the waters of Cedar River run through Black River into the Duwamish, but at high-water stages in Cedar River the direction of the current is temporarily reversed and a considerable portion of the waters of Cedar River flows

into Lake Washington until the water in the lake is raised to the level of the flood water at the mouth of Cedar River. A rise of 1¼ feet is sufficient to produce a slight current toward the lake. The shoal at the foot of Lake Washington, about 300 acres in extent, has been formed by the deposition of sediment brought down Cedar River during floods. The drainage area of Cedar River is 180 square miles.

Black River carries the level of Lake Washington to a point about 500 feet above the mouth of Cedar River, and then falls over a rough cobblestone bottom, with a current of from 4 to 5 miles per hour, during low-water stage, for a distance of 1,400 feet. Below this rapid there is a current of about 3 miles per hour to the Duwamish. The average width of Black River is about 100 feet.

Black River flows through the western and northern portions of a broad valley, part of which has been cleared and improved, but the greater proportion is low and swampy and covered with a dense growth of brush. The town of Renton, situated on the left bank of Cedar River, three-fourths of a mile above its mouth, has a population of 400, according to the census of 1890, engaged principally in farming and coal mining. The coal and farm produce are shipped to market over the Columbia and Puget Sound Railroad. The Franklin branch, down the Cedar River Valley, joins the Newcastle branch at Renton. The main line then crosses Black River 1¼ miles below the lake and follows the base of the ridge on the north side of Black River to the Duwamish Valley; then along the east side of the Duwamish Valley to Seattle. Franklin, the terminus of the Franklin branch of the Columbia and Puget Sound Railroad, is located on the right bank of Green River. The distance in an air line from the end of the Columbia and Puget Sound Railroad track to the main line of the Northern Pacific Railroad is about 2 miles.

Renton is the terminus of the Seattle and Rainier Beach Electric Railroad, which crosses Cedar River 2,000 feet above its mouth, Black River, at the foot of the lake, and then follows the west shore of the lake to Rainier Beach, a point 4 miles from the foot of the lake. It then follows the base of the ridge on the west through a narrow valley to Seattle.

The survey of Black River was commenced November 4 and completed November 11, 1897. It included 1 mile also of Cedar River from the Columbia and Puget Sound Railroad bridge at Renton to its mouth. At the time of the survey the river was at a low stage. At many places there was not enough water in Cedar River to float the sounding boat. Cedar River has a fall of 13 feet in the distance of 1 mile, and is obstructed by numerous bars and low islands. The bottom is of cobblestones and gravel. The greatest variation between high and low waters was found to be 8 feet. The river in this distance is crossed by four bridges, a detailed description of each of which is given in the appended list.*

Black River is a shallow stream, with a ruling depth of about 2 feet at low water. The channel is narrow and crooked and is obstructed by several gravel bars. The banks are covered with a dense growth of alder, willow, and vine-maple brush, which extends to and overhangs the low-water line. The total fall from Lake Washington to the Duwamish, a distance of 3.65 miles, is 12.08 feet, or at an average rate of 3.31 feet per mile. There are five bridges across Black River. All of these are fixed spans, except the bridge at the foot of the lake. These bridges vary from 8 to 12 feet in the clear above extreme high water.

A cross section of Black River was taken at the county bridge next below Cedar River, with a view at some future time of determining high and low water discharges. A base was measured on the east rail of the bridge and a tack driven at every 2 feet. The 10-foot distances from southeast end of bridge were marked with yellow paint. The depth of the water at each 2-foot distance was taken to the nearest hundredth of a foot.

During the progress of the survey of Black River a house boat 40 feet long by 12 feet beam was constructed at Kent. This was completed and ready for the party as soon as that survey was finished.

The variation between high and low waters on Black River was hard to determine, as the whole bottom is flooded, leaving few reliable high-water marks. The greatest variation noted at the lake is 3.3 feet; at the mouth of Cedar River about 5 feet; at the county bridge next below Cedar River about 10 feet; and at the Duwamish about 14 feet.

The survey of the White River was begun on November 13 and completed on November 27, 1897. The survey of the Duwamish was completed on December 12 and of Duwamish Bay on December 22, 1897.

During the whole of this time the weather was most unpropitious. The precipitation in the period occupied in making the survey was 16.58 inches. The average precipitation at Seattle for the last seven years was 38.58 inches per year.

On account of the heavy rains and of Chinook winds the river was at a high stage during the greater part of the time. It reached flood limits on November 19 and 20,

* Not printed.

1897. The continual fluctuations of the river made it necessary to establish gauges at several points. These were read regularly during the progress of the survey.

The upper gauge is nailed to a pile on the inside of a bulkhead on the left bank of White River 470 feet above the county bridge, known as the Alvord Bridge, 1 mile south of Kent. The zero of the gauge is at an elevation of 35.33 feet above the Puget Sound datum plane. A reading of 2.6 feet on this gauge corresponds with the stage of low water of November 3, 1897. This is said by the residents near by to be "as low as the river ever gets," and is the stage to which all soundings in the river have been reduced.

A second gauge was established 1 mile below the mouth of Black River. This gauge is nailed to a pile on the right bank of the Duwamish River 1,400 feet below the Northern Pacific Railroad station at Black River Junction. The pile is the lowest one of a long row. Zero of the gauge equals the low water of November 3, 1897, and is at an elevation of 18.34 feet above the Puget Sound datum.

A third gauge was established 800 feet below the Grant Street Electric Railroad Bridge at River Park. It is nailed to a bulkhead on the left bank of the Duwamish, immediately behind A. A. Brownlee's house. The zero of this gauge equals extreme low water, as determined from information given by residents at that point. It agrees almost exactly with the upper gauges. The zero of this gauge is at an elevation of 7.48 feet above Puget Sound datum.

A fourth gauge was established at Seattle. This is nailed to a pile on the south side of the wharf on Lane street, about 200 feet west of Railroad avenue. The gauge was set with the zero at mean lower low water, but all soundings in Duwamish Bay have been reduced to Puget Sound datum, which is 2.28 feet below zero of the gauge. The Puget Sound datum, as determined by the engineers of the State harbor line commission and of the State tide land commission, is the mean of the seven lowest tides observed during a period of one year—from August, 1891, to August, 1892—on the automatic tide gauge established by the United States Coast and Geodetic Survey at the foot of Madison street, and corresponds with a reading of 4.37 feet on that gauge. The average of the seven highest tides observed during the same period corresponds with a reading of 20.14 feet on that gauge, which equals 0.00 of the Seattle City datum, and shows a range of tide of 15.77 feet.

Besides the above gauges a temporary gauge was read every hour during working days. This gauge was read from point to point along the river, and was only taken up while the scow was being moved. At such times a record was made of the change in the water surface, and the temporary gauge was reset to correspond with that change. In this way an entirely accurate record of the stage of the river above the low-water plane was kept along with the survey. Considerable variation in the rise and fall of the river at the various points was noted. A diagram * is submitted showing at a glance the stage of the river at each of the river gauges, and at each camp along the river.

The difference between extreme low water and extreme high water at the first gauge is 17.6 feet. At the mouth of Black River the difference is 14 feet, and at River Peak it is 12 feet.

The current at White River at a stage about 6 feet above low water has a quite uniform velocity of from 2½ to 3 miles per hour. At a low stage it is probably about 2 miles per hour.

Soundings were taken across the river at an average distance of 200 feet, and diagonal lines were sounded between these transverse lines. Soundings are in feet and refer to the low-water stage of November 3, 1897, as far as the head of Edwards Island. At that point the tide comes in on each side of the island, and it was found that there was a difference of but two-tenths of a foot between the elevation of high water at that point and at Seattle, while all stations above Edwards Island showed a practically uniform slope of seven-tenths of a foot to the mile at high water. The head of Edwards Island was therefore taken as the dividing point between the river datum and the Puget Sound datum. The difference between the two data at this point is 3.76 feet.

A continuous line of levels was run for the entire distance. Benches were established at an average distance of 1½ miles. At each station were taken the elevation of the water surface of the high-water line, the general elevation of the surface of the ground, and of the top of the dike wherever found. The elevation of the low ground back from the river was also taken at intervals. The elevation of the lowest point of every bridge was also taken, in order to show the clear height.

White, Green, and Cedar rivers are subject to annual floods caused by the melting of the snow in the mountains at their sources. These floods usually occur in April or May, and last about two months. These rivers are also subject to floods at irregular periods during the fall and winter months. These are caused by a sudden melting of the snow by Chinook winds or by heavy rains. The highest water is usually

* Only index map is printed.

In November or in December. It is generally from fifteen to eighteen hours after a Chinook wind begins to blow before the rise is felt on the lower river. It usually takes about two days to reach flood limits. The greatest rise observed during the survey was of 8 feet in twenty-four hours. The greatest fall in twenty-four hours was 4.3 feet.

The total drainage area of the Duwamish River and all its tributaries is 1,533 square miles. The drainage area of each tributary is as follows:

Drainage area of—	Square miles.
White River above Green River	477
White River between Green and Duwamish rivers	60
Green River	399
Cedar River	180
Black River and all its tributaries, with exception of Cedar River	397
Duwamish proper	20
Total	1,533

During the early settlement of the valleys of the White and Duwamish rivers no attempt was made to confine the waters of the rivers within their banks by the construction of dikes. The river then overflowed the low ground of the valley, which afforded a natural safety valve to prevent excessive floods, and the greater portion of the sediment carried by the current was deposited on the land next the river. But as the valley became more thickly settled dikes were built and the water confined in a narrow channel.

The existing dikes conform to no system or general plan, but seem to have been built largely by individual efforts. They are generally too near the banks of the river, and thus prevent the natural increase of the cross section which should accompany the rise of the river. In many places there are no dikes for a considerable distance. In other places there are short dikes standing alone, with nothing to prevent the water from running around each end.

At the time of the highest water in White River, on November 19, a small quantity of the surface water was taken at a point where the velocity of the current was the greatest, in order to determine the amount of sediment carried in discontinuous suspension. There were no facilities for securing water from the bottom of the cross section. This sample of water weighed 7,055 grains. The sediment weighed 6¼ grains, or in the proportion of 1 to 1,085 by weight. This sediment seems to be about half sand and half clay or vegetable mold.

The banks of White River are covered with a dense growth of alder, willow, and vine-maple brush, which overhangs the low-water line. On the Duwamish the brush is not generally as dense. This brush affords complete protection against the washing and undermining effects of the current. In a majority of cases where the brush has been removed the river has begun to cut into the bank.

The average width of White River from the Northern Pacific Railroad Bridge to Black River is 150 feet and of the Duwamish River is about 250 feet. The course of each of these rivers is very tortuous, with numerous sharp bends and elbows. In some instances the direction of the current swings through an arc of 150° in a distance of from 300 to 500 feet. Bars are found usually on the inside of the sharp bends and in the straight reaches of the river where the current slackens. Above Black River there is but one bar with a depth of less than 4 feet of water. On the Duwamish there is a channel nowhere less than 4 feet in depth from Black River to a point 3½ miles above the mouth, where the ruling depth is 3 feet at low water. This shoal extends to the mouth of the river. At many points the depth is less than 2 feet. At the mouth the depth is about 1 foot at extreme low water, and from there to deep water, a distance of 2½ miles, extend mud flats, bare at low water. I am informed by tugboat captains that it is not possible to row a skiff into the mouth of the river at extreme low water. This shoal has been formed by the deposition of the sediment brought down by the current, which here meets the incoming tide and is checked sufficiently to allow the sediment to drop. This point where the tide checks the current, varying with the stage of the tide and of the river, swings back and forth as far down as deep water in Duwamish Bay and as far up as Georgetown. The reach of river between Georgetown and the mouth has a width of from 400 to 600 feet. Duwamish Bay has a width of about 2½ miles.

White and Duwamish rivers are obstructed throughout by snags whose roots are embedded in the mud bottom, by overhanging trees, and by trees which have slipped bodily into the river through the undermining of the banks. The snags are instrumental in the formation of bars by causing eddies which catch a great deal of sediment. It is believed that the removal of these snags and trees is all the work that is necessary for the improvement of these rivers. The bar across White River 1¼ miles above its mouth carries only 2.7 feet of water at low stage. This bar is 400 feet in length. The removal of 800 cubic yards would give a channel of 4 feet in

exit for the flood waters, but the evidence shown by the history of the river is that one good navigable channel may be maintained from a short distance inside the tide flats up the river to Mount Vernon, and that one channel is best not only for navigation, but also for the protection of the farms along the river banks.

In his letter transmitting this report Captain Taylor states:

In my opinion the continuance of the work which has heretofore been carried on in the Skagit River—that is, snagging—is of the utmost importance to the navigation of the river, and so far as this is concerned the improvement is a worthy one and justified by the interests of the commerce involved, but, for the reasons stated in the report, I am of the opinion that no further improvement is justified at the present time.

These views are concurred in by Col. Charles R. Suter, Corps of Engineers, the division engineer.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., December 11, 1897.

GENERAL: I have the honor to submit the following report of a survey of the "Skagit River from mouth to the town of Sedro, Wash.," made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The Skagit River, which is the largest river in western Washington, rises in the Cascade Range of mountains in British Columbia, and, flowing in a general southwesterly direction, crosses the international boundary line into the United States about 80 miles from the coast of Bellingham Bay. The part of the river included within the United States is something over 130 miles in length. Following the main channel, the length of river embraced within the limits of the survey is about 28 miles.

For the first 18 miles below Sedro the river at ordinary stages flows in one channel. It then forks into two branches, of which the larger, the South Fork, flows in a southerly direction, and the other, the North Fork, in a westerly direction into an arm of Puget Sound, known as Skagit Bay. Each of the two main forks subdivides into several smaller forks that find their way into Skagit Bay through separate mouths. None of these various mouths are navigable at low tide.

The portion of the river affected by the tide depends upon the stage of water in the river. At extreme low water in the river the tide is perceptible as far as the town of Avon, a distance of 15 miles from the main mouth.

Within the territory of the United States the Skagit River is joined by several important tributaries, among which the principal are the Baker and the Sauk. The Baker River, which rises on the west slope of Mount Baker, is joined at some distance from the Skagit by the Hukullum River, which rises on the west slope of Mount Shuksan. Mount Baker and Mount Shuksan, as well as several peaks around the head waters of the Skagit River in British Columbia, are covered with per-

petual snow. The Sauk River rises in the foothills of the Cascade Mountains in a region where the ground is free from snow but a very short time in the late summer.

The whole of the Pacific Northwest is subject to a peculiar warm, moist wind blowing off the ocean, usually from the southwest, which is known as the "chinook." A chinook wind may occur at any time of the year and may be felt by a large or small extent of territory at the same time. A chinook wind striking a snow field causes the snow to melt with abnormal rapidity.

The conditions surrounding the sources of the Skagit River are therefore such that a flood in the lower river is liable to occur almost any day in the year. A chinook wind will usually cause a marked rise in the lower river about thirty-six hours after it begins to blow, the amount of the rise depending upon the intensity and warmth of the wind and the amount of fresh snow upon the mountains.

During the year 1896 no less than three floods occurred in the Skagit River, due to the conditions above described. These occurred in January, June, and November. The flood of January reached a stage of 22 feet above low water on the gauge on the Great Northern Railroad Bridge, 6 miles above Mount Vernon; the flood of June reached a stage of 20 feet, and that of November a stage of nearly 24 feet on the same gauge. The elevation of the river bank in the vicinity is 21 feet above low water, so that during two of the floods in 1896 the river overflowed its banks above Mount Vernon. Protection from these overflows is one of the principal objects which the residents of the Skagit Valley desire to have accomplished by the improvement of the river.

The Skagit River is navigable at all stages of the river and tide from its mouth to Mount Vernon, a distance of 11 miles, and at all stages, except extreme low water, it is navigable to Avon, 3 miles above Mount Vernon. During extreme high water boats in past years have ascended the river as far as "The Portage," which is said to be 95 miles from the mouth. During ordinary high water boats can go as far as Sauk River, which is said to be 68 miles from the mouth, but at present they rarely go above Lyman, which is about 36 miles from the mouth of the river.

The regular navigation of the river is small in amount, being confined to one boat making triweekly trips between Seattle and Avon, but the result of this navigation is important in the regulation of transportation rates. During the higher stages of the river large rafts of logs are towed down from the upper river, and on high tides small boats and scows navigate many of the sloughs or branches of the lower river and take out large quantities of grain, so that the aggregate of the navigation is of considerable magnitude and importance.

The chief obstructions to navigation in the lower river are the snags which accumulate with every freshet. Between Mount Vernon and Avon there is one bar which prevents navigation at the extreme low water.

Between Avon and Sedro there are three bars or riffles, which can not be crossed except at the higher stages of the river. In front of the delta, formed by the mouths of the Skagit River, are extensive tide flats, bare at low water. The waters of the river, as soon as they are outside the high-tide line, spread out over these tide flats in many ill defined and changeable channels. Boats can cross these tide flats and enter the river only when the tide is at or above half-tide stage.

The improvement of the Skagit River, which is of the greatest importance to navigation, is the improvement which has been carried on for

a number of years past, viz, removing the snags which lodge in the river channel. For this purpose a snag boat has been provided, which works on the Skagit River and other rivers flowing into Puget Sound, where the conditions are much the same as on the Skagit. But on account of the larger size of the Skagit River, the greater number of snags, and the greater interests involved the principal part of the snag boat's time when in commission has been spent on this river.

The first snag boat was built in 1882. From that time until the act of June 3, 1896, was passed the appropriations provided for operating the boat were so small that she could not be operated more than a small part of each year, and the time she was in commission was only sufficient to enable her to remove the worst obstructions which were in the actual steamboat channels and rendered navigation hazardous. During her fourteen years of service the boat had also become rotten and weak, so that great care had to be taken in using her. The appropriation of June 3, 1896, was sufficient to permit of rebuilding the snag boat, and providing some additional appliances which experience had demonstrated were necessary, and to permit of operating her continuously throughout the past year. With this boat there have been removed from the Skagit River, since she was put in commission in December, 1896, after rebuilding, a total of 2,745 snags, ranging in diameter from 8 inches to 10 feet, and averaging about 30 feet in length, and 513 leaning trees, which were threatening to fall in and become obstructions, have been cut from the banks and disposed of. In addition to the above, several jams were broken up so that the bulk of them floated off. It is, I believe, admitted by all who are acquainted with the river that it had never been in so good a condition for navigation as it was in the early part of November, 1897. On the 18th and 19th of November, 1897, a freshet occurred which left several bad jams in the river. The snag boat was on the river at the time of this freshet and immediately commenced work on these jams.

During the past year almost the entire time of the snag boat has been given to the Skagit River and but a small part to all the other rivers included in the appropriation for "improving Puget Sound and tributary waters." It is possible that another snag boat may be needed in order that the entire time of one may be devoted to the Skagit River, or both be employed in cases of emergency, and the other be used on the other rivers needing improvement. A few months' more work with the one will settle this question conclusively.

I have carefully considered the advantages to navigation to be derived by other methods of improvement, such as dredging, dike building, revetting the banks, and straightening the river, and have been forced to the conclusion that they are not sufficient to justify the expense.

Dredging could be expected to benefit navigation only at the mouth of the river, as the depth of water from a short distance inside the mouth to Mount Vernon is ample, and above Mount Vernon the character of the river and navigation are such that it is impracticable to benefit navigation by that means. If a channel were dredged from deep water inside the mouth to deep water outside, boats could then enter and leave the river independent of the tide, so that they could run on a fixed time-table. But aside from their more regular hours of leaving I do not believe any material advantage would result. It would not result in the lowering of rates nor the increase of business, unless, possibly, a slight increase in the passenger business, which is a small and unimportant part of the whole. There is now one boat, which is supposed to run according to a time-table varying with the tide, but

constructed at the mouth of the river was the cause of the shoaling of the different mouths, and consequently is to blame for the overflows of the Skagit Valley.

As nearly as I can ascertain, the following is the history of the Skagit River:

The bottom land along the lower part of the Skagit River was formerly covered with a body of very large and fine cedar trees. The mills on Puget Sound formed a ready market for the timber, which was cut into logs and shingle bolts. These conditions early attracted settlers to the Skagit River bottom. As the land was cleared of the timber it was found to be exceedingly rich and fertile, but much of it, however, was marshy and swampy. The money obtained from the cutting of the timber was used for clearing the land and protecting it with dikes. At first it was necessary only to build low dikes, as the floods did not attain a great height in the lower river.

In the early days what is known as the Old Main River was the principal outlet of the Skagit River. It is reported that in the early days boats drawing 10 to 12 feet could easily navigate this branch as far as Fir, about 5 miles up from the mouth. Prior to 1879 a log jam, which was nearly a mile in length and almost completely covered the river, existed near where the present town of Mount Vernon is located. During freshets this jam obstructed the free flow of water and caught all logs and drift. The obstruction caused by this jam to the free flow of the flood waters prevented the low lands farther down the river from being flooded, but it caused the flooding of the entire country known as the Olympia and Beaver Marsh country, to the west of the Skagit River, between the present location of the town of Avon and Padilla Bay.

About the year 1879 the Mount Vernon log jam was cut by private enterprise. After it was cut up the greater part of it went out, and, from what I have been able to learn, much of the drift which was floated out from this jam lodged in what was then the main steamboat channel, Old Main River, and completely closed it. Since the breaking up of the log jam and the construction of dikes in the river, confining the waters of the river and preventing them to a very great extent from spreading over the adjacent country, the floods in the lower river have naturally increased in height. The country to the west of Avon, however, has been to a very great extent reclaimed, and now contains many of the richest and most valuable farms in the State of Washington.

In order to facilitate the log business on the Skagit River, a boom company was organized and commenced operations in the lower river about the year 1882. The boom was first put in what was known as Tom Moores Slough, where it remained for about two years. At the end of that time Tom Moores Slough was so filled up that logs could not be rafted through it. From Tom Moores Slough the boom was moved to what is known as Freshwater Slough, from Freshwater Slough to Deep Slough, and from Deep Slough to Log Slough. At the time the boom was moved from one slough to another each slough in turn was a navigable slough or entrance to the river, and each in turn filled up with drift so as to prevent boats from passing through it. The one navigable slough which is now left is known as Steamboat Slough. The booms may have helped the shoaling of the various sloughs in which they were located, but, judging from the results of the recent flood, such shoaling would have been brought about by natural causes, whether the booms were there or not.

It appears, therefore, that each of these several sloughs has been navigated, and that in each the boom was placed and soon after the

placing of the boom the slough became unnavigable; but it does not appear that all of these sloughs, or more than one of them, for that matter, were navigable at any one time. I have been informed by an old settler on the river that when he first came there Steamboat Slough was so small that a rowboat could not be rowed through it. It has cut out and enlarged to its present size since the former navigable channels closed up. At the present time Steamboat Slough forms a good navigable channel. If all of the sloughs were opened so as to afford free exit to the waters, it would be but a short time before they would be closed up so that none of them would be navigable.

In my opinion, the only manner in which the farmers of the Skagit Valley can get relief from the disastrous freshets which visit them is by a proper system of diking. The State law is very full and explicit in regard to diking. It fully provides for the formation of diking districts, the appointment of dike commissioners who shall have charge of all matters relating to the dikes, the assessment and collection of taxes and all other matters pertaining to the subject of dikes. I am of the opinion that the greater part of the trouble on the Skagit River is due to the incomplete system of dikes. The river is divided into several diking districts, but I do not understand that any one general and systematic plan for the construction of dikes for the lower river has ever been agreed upon. In some places the dikes seemed to be unnecessarily high, in others dangerously low, and in a good many places they are weak and thin and for long distances they are entirely too near the river banks. The placing of the dikes so near the river banks confines the waters so much that at times of freshets an abnormal rise is produced, and it also exposes the dike to the swift current, which soon washes it away. The greater part of the breaks in the dikes along the Skagit River within the past two or three years have been due to this cause, or to the fact that the dike was so near the bank of the river that the bank gave out underneath and actually tumbled the dike into the river. It appears to me that the proper solution of this problem requires the formation of the entire part of the Skagit Valley needing dike protection into a single diking district and the appointment of a competent experienced civil engineer to take entire charge of the building and maintenance of all the dikes on the river.

On the 18th and 19th of November the Skagit River was visited by the greatest freshet in the history of the river. It has been claimed that had the different mouths of the river been opened up the waters of this freshet would not have risen as high as in previous years and that they would have run off much sooner than they actually did. This freshet was caused by a Chinook wind of unusual warmth and intensity striking a large amount of freshly fallen snow, and the results were felt over the entire State of Washington, the northern part of Idaho, and the western part of Montana. Not only was the Skagit River the highest ever known, but all of the other rivers of Washington reached an unusual height. The Skykomish River rose many feet higher than ever before, the Kootenai River, in Montana, rose 22 feet in twenty-four hours, and the Clearwater River, in Idaho, reached a point higher than has been known at the same season of the year since 1862.

The Everett and Monte Cristo Railroad, running from Everett up the Stillaguamish River to the Monte Cristo mines, was practically wiped out of existence for a distance of 30 miles. The Great Northern Railroad was damaged so that it was two weeks before any trains could run, and the Northern Pacific Railroad was damaged more or less on both its Cascades divisions and Portland divisions.

The town which suffered the most in proportion to its size of any on

the Skagit River was the town of Hamilton, which is so far up the river that no possible opening of the mouths of the river could have had any effect on the height of the water at that place.

From the extent of the floods and the damage caused in other places it is very evident that no amount of opening out of the mouths of the Skagit River would have prevented the floods in this river. As a matter of fact the most disastrous breaks in the dikes of the Skagit River were in the vicinity of Mount Vernon, some 12 miles from the mouth of the river and too far to derive any benefit from the opening of the mouths of the river, and the higher up the river one goes the greater the freshet appears to have been. At Sauk River, 68 miles from the mouth, the water reached a stage 6 feet 8 inches above the freshet of November, 1896; at Lyman, 32 miles below Sauk River, it was 2 feet 9 inches above last year's flood; at Sedro, 8 miles below Lyman, it was 1 foot 6 inches, while in the vicinity of Mount Vernon it was but about 10 inches above last year's flood.

In addition to clearing the mouths of the river, it is desired to have channels dredged out across the tide flats to deep water, so as to take the water off more rapidly.

The Skagit River delta is nearly 8 miles wide. Along this delta the river empties into Skagit Bay through a dozen or more mouths. The cost of dredging a channel from each of these mouths would be tremendous, and a channel dredged from any one of them would increase in so insignificant a proportion the available high water outlets that its effect would not be noticeable. As shown above in this report, to dredge even a small channel suitable for navigation would cost a large sum of money, and to dredge a channel which would carry off the waters of a large river would certainly be a Herculean undertaking. Nor does it appear from a study of the high-water levels that even if a channel large enough to carry the whole river were dredged from the mouth of Steamboat Slough to deep water the high water level would be lowered so as to produce any great benefit. The level of the water in the freshet of November, 1896, at the Mount Vernon Bridge, as shown by the marks on the bank, was 36.2 feet above extreme low water in Skagit Bay, or about 20 feet above extreme high water in Skagit Bay. From this point there was a nearly uniform slope for 1½ miles, in which distance the river fell 1.2 feet, or at the rate of eight-tenths of a foot per mile. There was then a drop of 2.6 feet in 2,000, or at the rate of 6.8 feet per mile. This was probably due to breaks in the dikes. For the next 6¼ miles there was a nearly uniform slope of 1.8 feet per mile; then a drop of 3.8 feet in 5,800 feet, or at the rate of about 3½ feet per mile. From this point to the mouth of the river, about 3 miles, there was a total drop of only about 1 foot. At the mouth of the river the flood level was practically identical with extreme high water in Skagit Bay.

While dredging might possibly increase the slope of the flood water for a short distance back from the mouth at low tide, I do not see how it could be of much benefit during high tides. If dredging would prevent the tide rising in the river it would be of some benefit to dredge, but as long as it does not do this, it does not appear that the dredging would do much good, for no matter what might be the slope of the water surface in the river during low tide, at high tide the slopes and heights would be the same as they are now. As a matter of fact the highest water near the mouth of the river is caused by spring tides, regardless of the stage of the river. The height of these tides can be counted on with considerable certainty, and the dikes are built high enough to

V V 19.

SURVEY OF OKANOGAN RIVER, WASHINGTON.

[Printed in House Doc. No. 211, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 7, 1898.

SIR: I have the honor to submit the accompanying report of December 18, 1897, with map,* by Capt. Harry Taylor, Corps of Engineers, of the results of a survey of Okanogan River, Washington, made to comply with requirements of the river and harbor act of June 3, 1896.

The improvement proposed by Captain Taylor contemplates rock removal, construction of wing dams, and snagging, at an estimated cost of $30,000, to permit navigation from the mouth of the river to the international boundary line at all times of the year except during extreme low water.

In transmitting his report Captain Taylor expresses the opinion that the proposed improvement is a worthy one and is justified by the interests of commerce involved. His views are concurred in by Col. Charles R. Suter, Corps of Engineers, Division Engineer.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., December 18, 1897.

GENERAL: I have the honor to submit the following report† of a survey of the Okanogan River, Washington, made in compliance with the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The sources of the Okanogan River are in British Columbia. It crosses the international boundary line through Osoyoos Lake into the State of Washington in longitude 119° 25′ west of Greenwich. From this point it flows in a general southerly direction to its confluence with the Columbia River. The length of the Okanogan River within the United States is nearly 87 miles. The point of its junction with the Columbia River is 66 miles above Wenatchee, a town on the Great Northern Railroad. The Columbia River from Wenatchee to the mouth of the Okanogan is navigated throughout the greater part of the year. The Okanogan River has been navigated from the Columbia to the international boundary line during high water, and the lower part of the Okanogan River is regularly navigated for about four months in the year, during the summer high water.

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*Not reprinted. Printed in House Doc. No. 211, Fifty-fifth Congress, second session.
†All illustrations, except index map, omitted.

The valley immediately adjoining the Okanogan River ranges from 1 to 4 miles in width. Its soil is generally a light, sandy loam, growing sagebrush and bunch grass without irrigation, and when irrigated produces most abundant crops of hay, fruit, and vegetables.

The land on the east side of the river for its entire length belongs to the Colville Indian Reservation. The north half of this reservation has recently been opened up to mining locations, and some very good claims have been developed, although the majority of them have not been worked to any great extent. The south half of the reservation is inhabited only by Indians. These Indians are rather more thrifty than the average Indian, doing considerable farming and owning several small bands of cattle and horses.

The land on the west side of the river is practically all taken up, but, owing to the country being new and a great deal of it not having been surveyed by the Government and the general depression of the times, the settlers have not been able in many instances to make much improvement on their places. There are, however, a number of fine ranches along the shores of the Okanogan River, and the ranchers seem to be thrifty and their bands of stock improving. With better transportation facilities they will be classed among the most prosperous farmers in the State of Washington.

At an elevation of from 300 to 500 feet above Okanogan River there are several fine benches of slightly rolling table-lands, ranging in size from a few thousand acres to probably 50,000 acres. Upon these benches are a number of fine ranches, but a large portion of them are not farmed on account of the scarcity of water for irrigation. Where these benches are not farmed they produce an abundant growth of bunch grass and support large herds of cattle, horses, and sheep. The stock range in the Okanogan country is probably as good as any in the State of Washington, and, averaging from 15 to 50 miles on each side of the river, gives ample range for many thousand head of stock. It is stated by the settlers there that the winters are so mild that horses are seldom ever taken from the ranges and fed, and that only during the harder winters are the cattle taken in and fed, and then from not to exceed six weeks to two months.

The principal towns getting their supplies from steamboat transportation on the Okanogan River are Ruby and Concunully, which are tributary to the lower river, and Loomiston, Oro, and Golden, on the upper portion of the river. The towns on the upper river are compelled to freight their supplies by wagon from 20 to 35 miles to Okanogan City, which is the present head of ordinary navigation.

Almost all over the Okanogan country, for a distance of 40 miles on either side of the river are mining camps which get their supplies from these towns, the supplies being brought in during the season of navigation, which exists during the high stages of water in April, May, June, and July. In addition to the mining camps on the American side of the line, there are several on the British Columbia side which get their supplies from the stores on the American side.

It is claimed by mining men in that locality that if they could be sure of transportation from Okanogan City to connect with the Columbia River steamers, even for eight or nine months in the year, that the shipment of concentrates alone would keep a good steamboat running, even under the present conditions. There is considerable ore shipped from the Okanogan country during the higher stages of water, and when it

is possible for a Columbia River steamboat to enter the Okanogan River she is taxed to the utmost with freight and passengers for the head of navigation. It is stated that fully 75 per cent of the freight carried on the Columbia from Wenatchee is consumed in the Okanogan country, and that the greater portion of the passenger business is to and from the towns or mining camps in this valley.

The Okanogan River has a general width throughout its entire length of from 300 to 400 feet, and as a rule has a depth sufficient for light-draft navigation throughout the entire year. There are, however, a number of rapids upon which the water is shoal, and in a number of places also the river is obstructed by sunken rocks. The total fall of the Okanogan River from the international boundary line to its mouth in the Columbia is 164 feet, making an average of less than 2 feet per mile.

About 7½ miles from the boundary line the Okanogan is joined by the Similikameen River, which has a volume of water nearly equal to that of the Okanogan. From this point to its mouth in the Columbia the Okanogan is not joined by any stream of importance, so that its volume is but little increased from the time it leaves its junction with the Similikameen to its mouth.

The present head of ordinary navigation on the Okanogan River is Okanogan City, 43 miles above its mouth. Above this point there are but seven rapids which need improvement to render the river navigable to the boundary line at all ordinary stages of water. The worst obstruction on the river, however, is located but 7 miles above this point. This obstruction is what is known as McLaughlins Falls, where the river runs over a submerged ledge of rock which forms a dam across the river, backing it up and giving it a nearly vertical drop immediately below the rocks of about 4 feet.

Just above McLaughlins Falls the river makes a sharp turn to the right and then turns again to the left. At the point where the river turns to the right there is a high-water channel which leaves the river and enters it again below the falls. The distance across the neck of land following the line of the high-water channel is but about 400 feet, while it is about 2,600 feet around by the low-water channel. If a channel were cut across this neck of land it would lower the river above and make a more gradual slope, and as the water above the falls for some 3 or 4 miles is quite deep, the lowering of the water surface to the extent required would not cause any obstruction. It is estimated that the improvement at McLaughlins Falls can be made by the removal of 4,000 cubic yards of rock, at a cost of $1.50 per cubic yard.

In addition to this there are about 900 cubic yards of submerged rock between Okanogan City and the international boundary line which it would be necessary to remove and 500 feet of wing dam to be built. In the upper part of the river, below Osoyoos Lake, there are also quite a number of snags which should be removed.

Below Okanogan City there are 15 rapids or shoals which need improvement. The improvement needed at each of these places, however, is small, generally consisting of the removal of a few submerged rocks and the building of a short wing dam. It is estimated that all of the improvement required on the river below Okanogan City could be made by the removal of about 1,100 cubic yards of submerged rocks and bowlders and the construction of about 5,000 linear feet of wing dam.

The estimated cost of the improvement of the Okanogan River, so as

to permit navigation from the Columbia River to the international boundary line at all times of the year except during extreme low water, is as follows:

Removing 4,000 cubic yards rock, at $1.50	$6,000
Removing 2,000 cubic yards submerged rock, at $3	6,000
Building 5,500 linear feet wing dam, at $2.50	13,750
Snagging	2,000
Engineering, contingencies, etc	2,250
Total	30,000

Very respectfully, your obedient servant,

HARRY TAYLOR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

[First indorsement.]

U. S. ENGINEER OFFICE, PACIFIC DIVISION,
San Francisco, Cal., December 27, 1897.

Respectfully forwarded to the Chief of Engineers, United States Army.

I concur in the views of the district officer.

CHAS. R. SUTER,
Colonel of Engineers, Division Engineer.

V V 20.

SURVEY OF PEND OREILLE RIVER, FROM ITS SOURCE AT LAKE PEND OREILLE, IDAHO, TO THE TOWN OF METALLINE, WASH.

[Printed in House Doc. No. 235, Fifty-fifth Congress, second session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 14, 1898.

SIR: I have the honor to submit the accompanying report of December 28, 1897, with maps,* by Capt. Harry Taylor, Corps of Engineers, of the results of a survey of Pend Oreille River from its source at Lake Pend Oreille, Idaho, to the town of Metalline, Wash., made to comply with the requirements of the river and harbor act of June 3, 1896.

The upper part of this river, between Lake Pend Oreille and mouth of Priest River, has a channel from 500 to 1,000 feet wide, with a depth of from 25 to 50 feet at extreme low water. Five miles below the mouth of Priest River navigation is obstructed by Albany Falls, while below these falls the river is navigable at extreme low water, for boats drawing less than 6 feet, as far as the Blue Slide, a distance of 40 miles; and at a medium low stage (3 feet above extreme low water) it is navigable for such steamers as far as Box Canyon, a distance of about 60 miles, the obstructions in this part of the river consisting of sand and gravel bars and isolated rocks, but none are of a serious nature.

The most serious obstructions to navigation of the lower river are found in Box Canyon, where the river flows through a narrow gorge

* Not reprinted. Printed in House Doc. No. 235, Fifty-fifth Congress, second session.

3,600 feet long, in which the river passes over large rocks which are effectual barriers to navigation at low water. Below the canyon, as far as Metalline, there is a fairly good channel at all seasons of the year, and the river is navigable for about a mile and a half below Metalline to Metalline Falls, which form the limit of navigation on the lower river.

Captain Taylor states that above Albany Falls the river needs no improvement; that to pass Albany Falls a lock would be required, the cost of which may be roughly estimated at $300,000, but that no detailed estimate has been attempted, as there is not the slightest reason for its construction; also, that between Albany Falls and Box Canyon there are a few isolated rocks which can be removed at inconsiderable expense and to the great benefit of navigation, and that by the removal of certain submerged rocks and cutting off the worst of the projecting points Box Canyon can be improved sufficiently to enable boats to navigate it enough to bring out the products of the mines in the vicinity of Metalline.

An estimate is therefore submitted for the removal of 12,708 cubic yards of rock from the river at a cost, including contingencies, of $30,000.

In his letter transmitting this report to this office Captain Taylor states:

> In my opinion the proposed improvement of Box Canyon, as outlined in my report, is a worthy one and is justified by the interests of the commerce involved. The improvement of the river between Albany Falls and Box Canyon, to the limited extent of removing certain rocks, is also recommended, but aside from this work the interests of commerce involved do not justify the improvement of the river.

The views of Captain Taylor are concurred in by Col. Charles R. Suter, Corps of Engineers, Division Engineer.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. R. A. ALGER,
Secretary of War.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Seattle, Wash., December 28, 1897.

GENERAL: I have the honor to submit the following report of a survey of the Pend Oreille River, from its source at Lake Pend Oreille, Idaho, to the town of Metalline, Wash., made in compliance with the requirements of the river and harbor act of June 3, 1896, and assigned to my charge by your letter of September 5, 1896.

The Pend Oreille River, which flows out of the northwestern part of Lake Pend Oreille, is in reality only a continuation of a stream flowing into the northeastern part, and which is known as the Clark Fork of the Columbia. Aside from the Clark Fork the streams flowing into the lake are small, so that the volume of the Pend Oreille below the lake is but little greater than the volume of the Clark Fork above it.

Lake Pend Oreille consists of two main arms, one extending in a general easterly and westerly direction and the other extending in a southerly direction from near the eastern end of the east-and-west arm. Clark

a depth of from 6 to 18 feet, the obstructions consisting mainly of isolated reefs and bowlders and small gravel bars. Opposite the mouth of Priest River are several sand bars, but all of these lie close to the right bank of the river, while the channel follows the left bank. None of these obstructions interfere seriously with navigation.

Five miles below the mouth of Priest River and 2 miles above the boundary line between Idaho and Washington are Albany Falls, which form the only serious obstruction to navigation on that part of the river lying within the State of Idaho. Here the river is divided by a rocky island, having an area of 5 acres, the summit of which rises 60 feet above the water level. The river banks consist of almost perpendicular rock bluffs of about the same height as the summit of the island. The main channel of the river flows between the right bank and the island, and immediately over the falls is but 120 feet wide. These falls have a total descent of 6.8 feet, of which 6.4 feet is within a space of 100 feet. The Great Northern Railway crosses the river immediately above the falls, passing over the island referred to.

Below the falls the river is navigable at extreme low water for boats drawing less than 6 feet as far as the "Blue Slide," a distance of 40 miles. At a medium low stage—that is, say, 3 feet above extreme low water—it is navigable for such steamers as far as Box Canyon, a distance of about 60 miles. In this part of the river there are numerous obstructions, consisting for the most part of sand and gravel bars and isolated rocks, but none of a serious nature. The depth of water in the channel is not less than 6 feet at any point, but the channel is very sinuous and in places extremely narrow, particularly on the stretch of river below the "Blue Slide." The current varies according to the locality and width of the river, the maximum observed velocity being 6 miles per hour.

The most serious obstructions to navigation on that part of the lower river covered by the survey are found in Box Canyon, where the river flows through a narrow gorge 3,600 feet long, hemmed in by walls of limestone from 50 to 200 feet in height. At the entrance to the canyon the river is contracted to a width of 120 feet, and is but little wider at any point for a distance of a quarter of a mile. The current here attains great velocity and the depth of water exceeds 50 feet. About halfway through the canyon the walls widen out somewhat and the river is divided by a high rocky island, which almost blocks the canyon at this point. On either side of this island the river passes over large rocks, which are effectual barriers to navigation at low water. Below the island the canyon contracts again, although it is not so narrow as it is at the entrance, nor is the current so rapid. During the high-water period navigation would be possible were it not for the strong current and several projecting rocks which contract the river and leave but little room for the safe and proper handling of steamboats.

Below the canyon as far as Metalline there is a fairly good channel at all seasons of the year. There are numerous gravel bars and rapids, but none of them form serious obstacles. Below Metalline the river is navigable for about 1½ miles, or as far as Sullivan Creek. Here the river passes through another canyon, in which are several falls, known as the Metalline Falls, with an aggregate descent of probably 25 or 30 feet. These falls form the natural limit of navigation on the lower river.

The valley of the Pend Oreille is not over a mile in width between the lake and Albany Falls. A couple of miles below the latter point it widens out a little, and for a distance of 20 miles, or as far as Indian Creek, its average width is 2 miles. From Indian Creek northward

there is a wide stretch of low meadow land called the Calispell Valley, which is from 5 to 15 miles wide. Twenty miles below Indian Creek the mountain ranges approach again, and from here to the mouth of the river the valley of the Pend Oreille is not over 2 miles wide.

There are but two towns on the river. One is called Priest River, from its location near the mouth of that stream, in the State of Idaho. The other is Newport, situated at the boundary line dividing the States of Idaho and Washington. The former has a population of 125 and the latter about 200 inhabitants. Both of these towns are on the line of the Great Northern Railway. The country tributary to the Pend Oreille is sparsely settled, the white population not exceeding 700, exclusive of the two towns above mentioned. There are also from 50 to 100 Indians of various tribes living in the Calispell Valley, where they own most of the land lying along the right bank of the river. The white inhabitants are engaged in agriculture and mining, chiefly the former.

The products of the farms consist for the most part of hay and potatoes, in addition to the various vegetables raised for domestic use. Stock raising is also a considerable industry.

The mines of the locality yield lead, silver, and copper in quantity about in the order named. So far as could be learned but two mines are being operated at the present time. There are also deposits of bituminous coal at several points on the lower river, but they are too far from railways to make shipment profitable. The richest mineral camp in the region is at Metalline, Wash., where large bodies of galena exist, but, owing to the inaccessibility of this camp, none of the mines are shipping ore.

It was stated that upward of 300 locations had been made here and several claims had been patented. The ore runs from 30 to 80 per cent lead and is said to be excellent for fluxing purposes. The value of the ore of course varies considerably, running all the way from $25 to $60 per ton. Probably $40 at the smelter would be a fair average value. The cost of labor, tools, and powder is usually estimated at $5 per ton. Transportation from the upper end of Box Canyon to Newport, the nearest railroad point, is figured at $2 per ton. Adding to this $6 for transportation from Newport to the smelter at Everett, Wash., and $9 per ton for smelting, makes a total of $22 per ton as the cost of mining and transporting this ore and converting it into valuable form.

As Metalline lies below Box Canyon and is hemmed in on all sides by rugged and precipitous mountains, it is practically impossible at the present time to get this ore out except at prohibitive cost. It is believed that if Box Canyon were improved by the removal of the worst of the submerged rocks and points projecting from the canyon walls, so that steamers could pass through the canyon with safety, the export of the product of this camp would be profitable.

The ordinary commercial and shipping interests of the locality would not justify the large expenditure that would be required by a project for the general improvement of the river. The steamer *Red Cloud* is the only steamboat on the river at this time, doing a general local freight and passenger business between Newport and Ione. But two steamers, the *Bertha* and *Metalline*, have ever passed through Box Canyon, both having undergone great difficulty and danger in making the trip. The latter was taken through the canyon during the high-water season in the summer of 1894. In bringing the steamer back it was necessary to run a wire cable through the canyon, as she did not have sufficient power otherwise to stem the current. It is not probable that another attempt will be made under existing conditions.

Accompanying this report are two tracings, one showing Albany Falls and the other Box Canyon, and fourteen photographs of the river. A map of the entire river is being worked up and will be forwarded as soon as completed.

Above Albany Falls the river needs no improvement. To pass Albany Falls a lock would be required, the cost of which may be roughly estimated at $300,000. No detailed estimate has been attempted, as there is not the slightest reason for its construction. All the part of the country above the falls and tributary to the river and lake is now served by two railroads—the Great Northern and the Northern Pacific. Connection with the river below the falls is made by the Great Northern at Newport. The only possible advantage which a lock at Albany Falls could give would be to enable the products of the lower river to be delivered to the Northern Pacific Railroad at Sand Point instead of to the Great Northern at Newport. Practically the only industry which will ever justify the expenditure of much money for the improvement of this river is that of mining; and as the products of the mines must be sent over the Great Northern to the smelter at Everett, which is on the line of the Great Northern, but not on the line of the Northern Pacific, the construction of a lock at Albany Falls above the point of connection with the Great Northern could not benefit the mining industry. If there were any real demand for the transfer of the products of the lower river to the upper, arrangements could easily be made whereby cargoes could be transferred without a lock for not to exceed 15 cents per ton. Moreover, if a lock were constructed at this point the Great Northern Railroad would be compelled to change its present bridge and put in a draw span before the lock could be used. I believe there would be difficulty in showing that the needs of commerce were sufficient to demand such a change.

Between Albany Falls and Box Canyon there are a few isolated rocks, which can be removed at inconsiderable expense and to the great benefit of navigation.

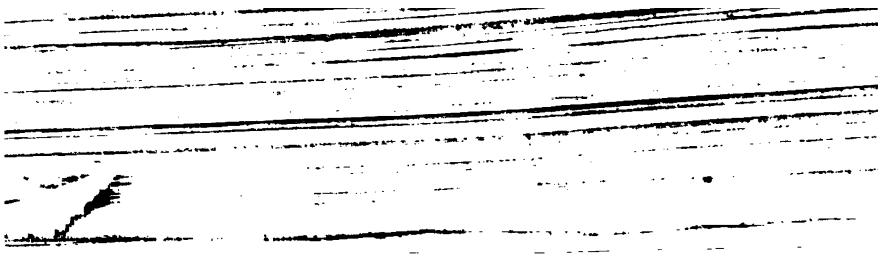
If the Box Canyon were passable, the mines around Metalline would be able to ship their ores with profit, and a large and valuable mining country opened up. It is not probable that the canyon can ever be improved so that boats can pass through without "lining," or at all stages of the water, but it appears that by the removal of certain submerged rocks and the cutting off of the worst of the projecting points the canyon can be improved sufficiently to enable boats to navigate it enough to bring out the products of the mines. The rock to be removed is mostly limestone, which can be easily blasted and the fragments allowed to fall in the deep water of the canyon.

Following is a statement of the quantities and estimate of the cost of this improvement:

Box Canyon.	Submerged.	Above water.
	Cubic yards.	*Cubic yards.*
Submerged rocks *a*, *b*, *c*, *d*, *e*, and *f*	94	.....
Projecting point A	466	233
Projecting point B	1,333	1,777
Projecting point C	555	740
Projecting point D	400	2,666
Projecting point E	444	3,000
	3,292	8,416
Isolated rocks between Blue Slide and Box Canyon, estimated	1,000	.....
Total	4,292	8,416

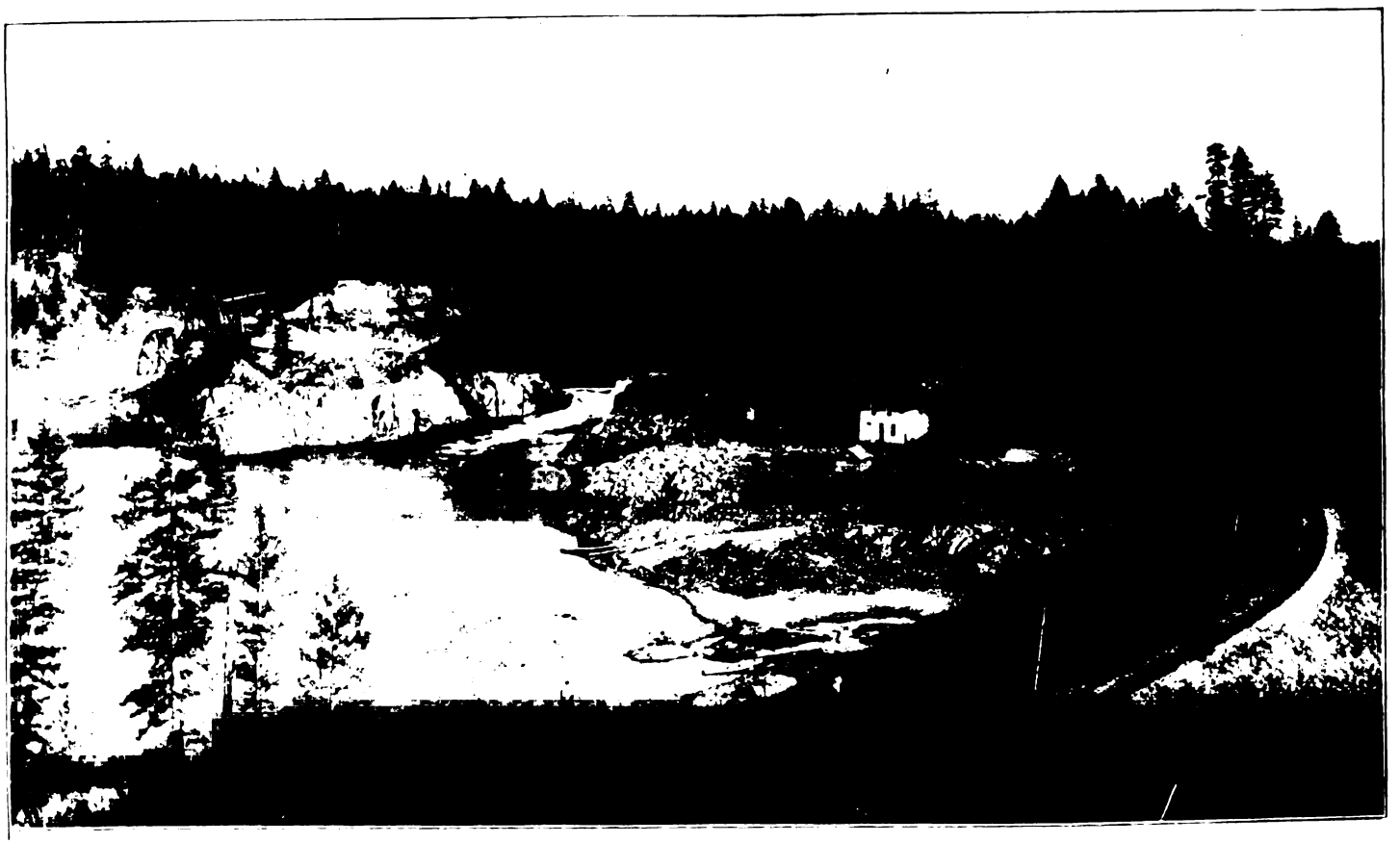
LAKE PEND D'OREILLE, FROM HOPE, IDAHO. SEPTEMBER 4, 1897.

MARKHAM, IDAHO, AND PEND D'OREILLE RIVER FROM HOODOO MOUNTAIN.
SEPTEMBER 17, 1897.



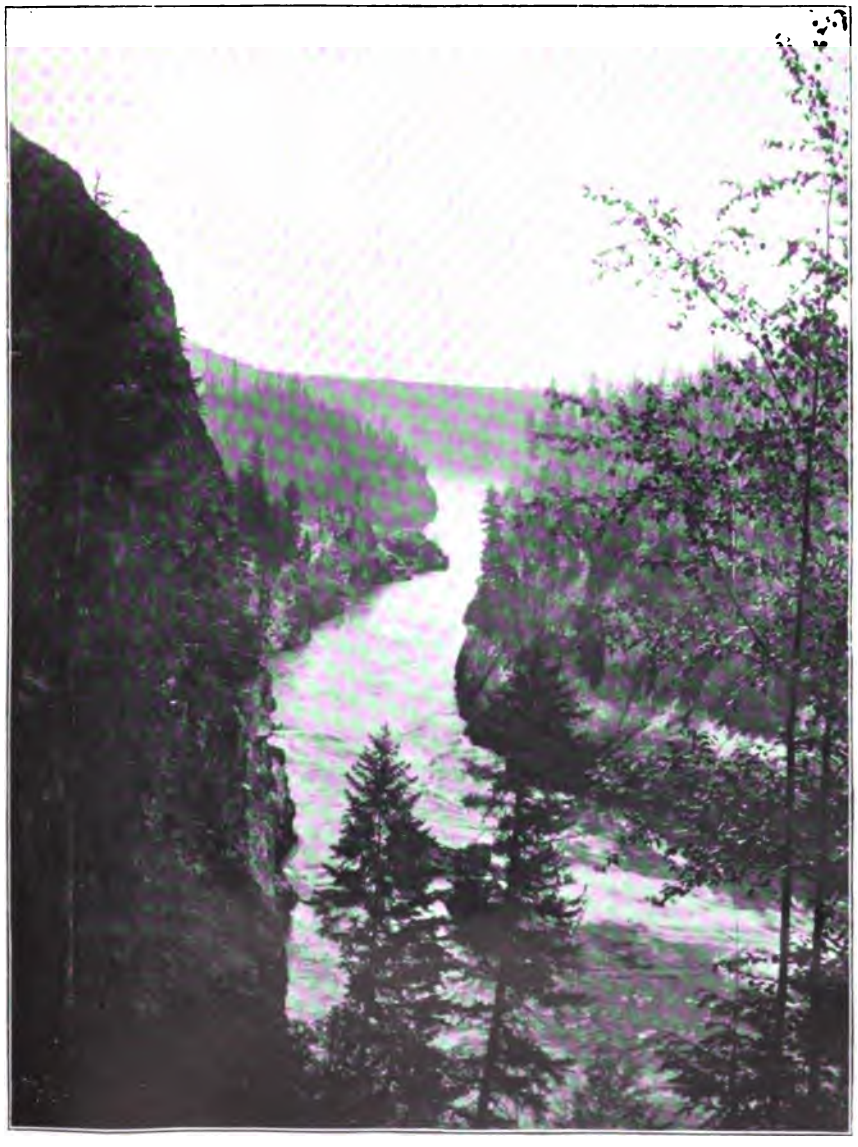
LOOKING UP THE PEND D'OREILLE. ABOUT 1 MILE ABOVE BOX CANYON.
NOVEMBER 4, 1897.

UPPER ENTRANCE TO BOX CANYON, PEND D'OREILLE RIVER, WASHINGTON.
NOVEMBER 4, 1897.



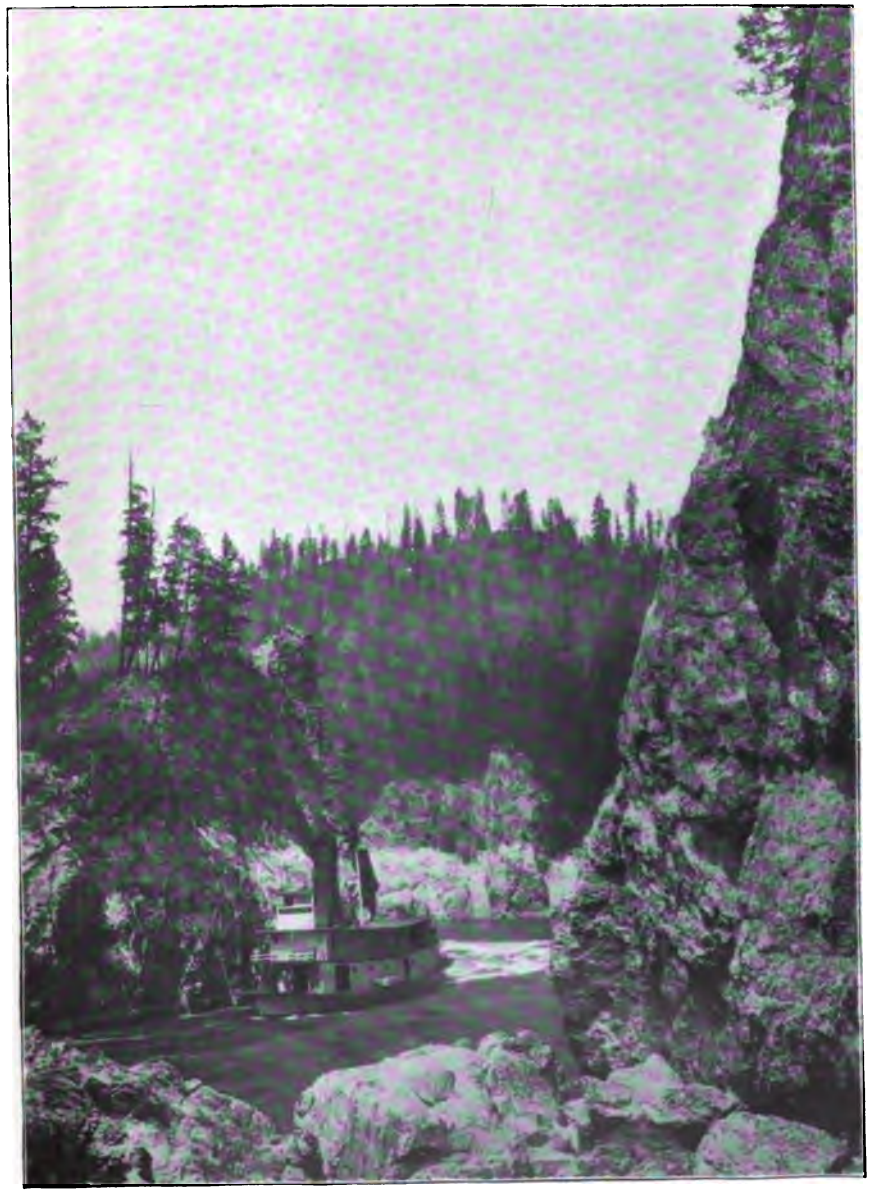
ALBANY FALLS, PEND D'OREILLE RIVER, IDAHO.

STEAMBOATING UNDER DIFFICULTIES. HALFWAY THROUGH BOX CANYON, PEND D'OREILLE RIVER, WASHINGTON.



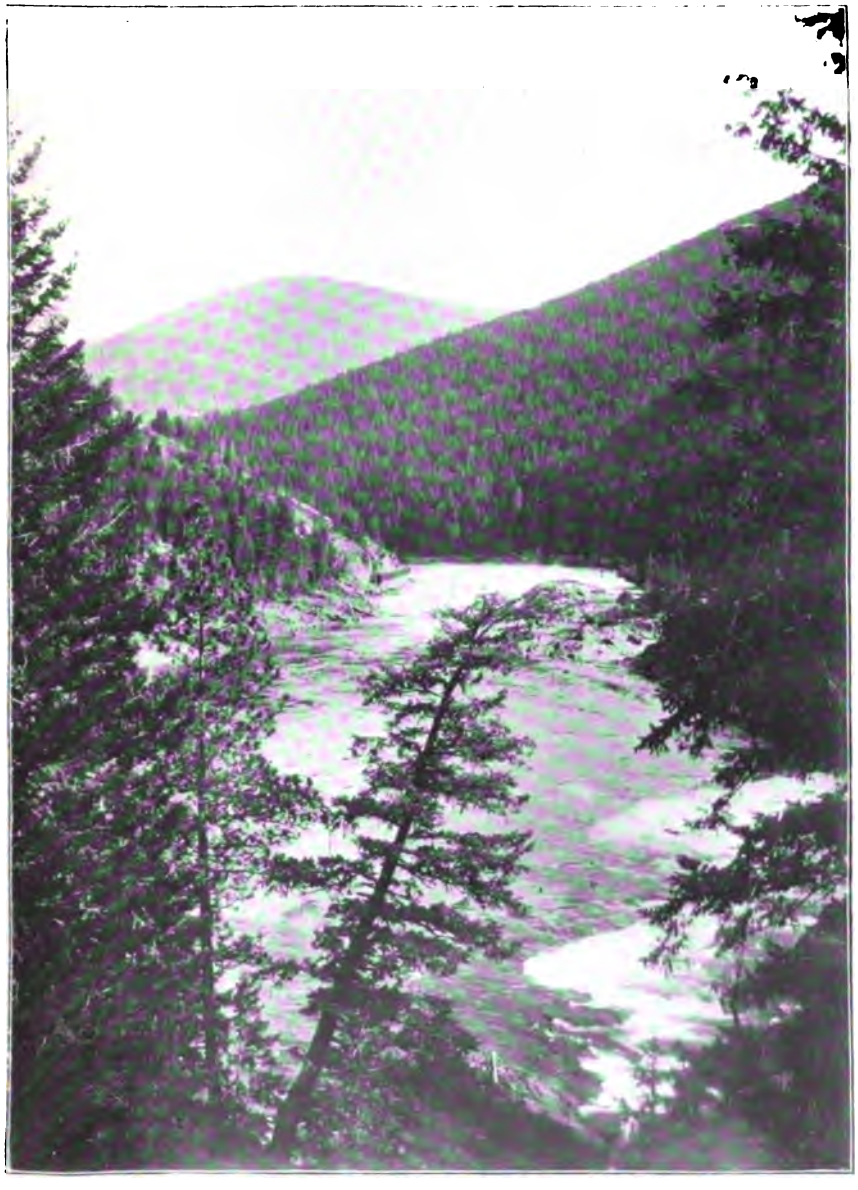
LOOKING UP BOX CANYON, PEND D'OREILLE RIVER, 5 MILES ABOVE METALLINE, WASHINGTON.

PEND D'OREILLE RIVER, WASHINGTON. BOX CANYON AT HIGH WATER.



STEAMER METALLINE IN BOX CANYON, PEND D'OREILLE RIVER, WASHINGTON.

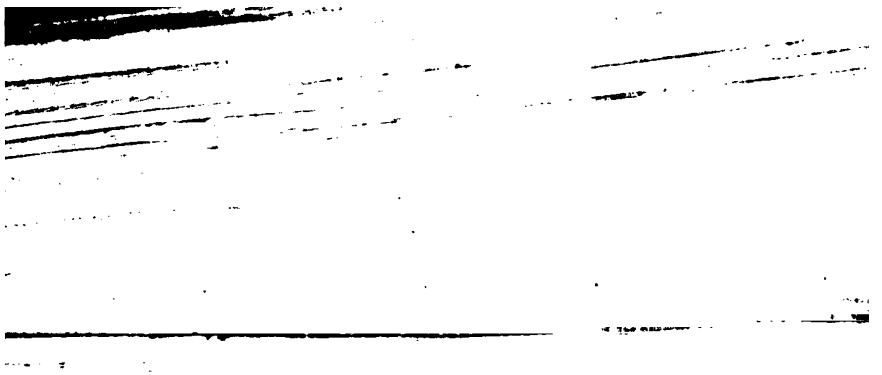
BIG CANYON, PEND D'OREILLE RIVER, 3 MILES BELOW METALLINE, WASHINGTON.

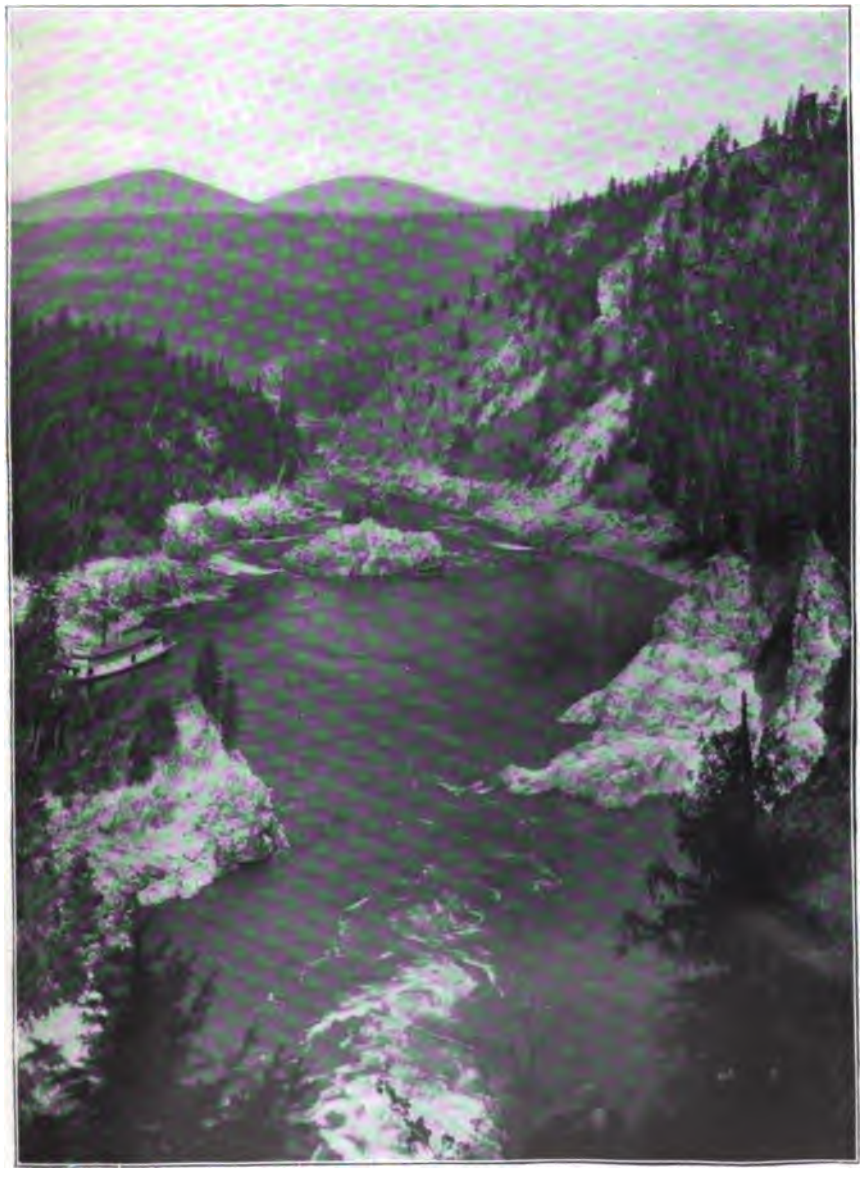


PEND D'OREILLE RIVER, 7 MILES ABOVE THE CONFLUENCE WITH THE COLUMBIA.

ALBANY FALLS, PEND D'OREILLE RIVER, IDAHO.

NOTE.—This picture shows the river at high water and the Great Northern Railway bridge in its original position.





LOOKING DOWN BOX CANYON, PEND D'OREILLE RIVER, 5 MILES ABOVE METALLINE, WASHINGTON.

APPENDIX W W.

SUPERVISION OF THE HARBOR OF NEW YORK.

REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1898. SUPERVISORS, LIEUT. COMMANDER W. L. FIELD, LIEUT. COMMANDER N. J. K. PATCH, AND LIEUT. JOHN F. PARKER, UNITED STATES NAVY.

WAR DEPARTMENT,
OFFICE OF THE SUPERVISOR OF THE
HARBOR OF NEW YORK,
New York, July 9, 1898.

GENERAL: I have the honor to submit the following report of the work done by this office for the fiscal year ending June 30, 1898; also an estimate of the amount required for the fiscal year ending June 30, 1900.

The steam tugs *Argus* and *Nimrod* have been overhauled as much as the appropriation permitted. The boiler of the *Nimrod* is bad, and it will be absolutely necessary that she have a new boiler during the coming fiscal year, and I would recommend that a special appropriation of $6,500 be asked for this purpose. An effort was made during the past fiscal year to run the boats in the most economical manner and fit a new boiler in this vessel from the current appropriation, but it was found impracticable, the amount allowed being barely sufficient to meet ordinary expenses.

The *Argus* is the most expensive and least useful of the patrol boats. By reference to former annual reports of this office I find the following on page 1 of the report by Captain Rodgers for the fiscal year ending June 30, 1892:

> In reference to the repairs to the *Argus* on this and the last occasion, it is a question whether she was worth the expenditure. It is possible that one more year's service may be got out of her, but I doubt whether it would be expedient to spend any more money on her.

Since then she has been almost constantly under repairs, and is at all times unreliable. However, unless kept in a reasonably serviceable condition, the efficiency of the patrol would be considerably crippled until another vessel could be obtained to take her place, as contractors and others keep themselves well informed of the efficiency and seaworthy qualities of the vessels on patrol duty and govern themselves accordingly. She requires continual repairs, and is too small for outside work. I would recommend that a new boat be built to take her place, as it is for the interest of this work that all the tugs on this duty should be able to go outside as far as the Sandy Hook Light-Ship, in any weather that a tow can do so; $45,000 would build a suitable boat for this duty.

hereby strictly forbidden, and every person violating the foregoing provisions shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by a fine of not more than two hundred and fifty dollars nor less than five dollars, or imprisonment for not more than six months nor less than ten days, one-half of said fine to be paid to the person or persons giving information which shall lead to the conviction of such misdemeanor.

SCOWS TO RECEIVE ASHES, ETC., FROM STEAM TUGS AND VESSELS.

SEC. 881. The various scows employed by the city of New York, or by the contractors for removing ashes, garbage, and refuse of said city, while moored at the various dumping boards of said city, are hereby designated and required to receive directly any and all ashes or rubbish from any steam tug or steam vessel in the harbor, and in addition to the foregoing provisions two or more scows shall be located at such points within the harbor as the supervisor of the harbor may direct for the special use of boats and vessels wishing to discharge ashes or rubbish.

The operation of these sections promotes the work of this office by insuring prompt trial of minor offenders, and the facilities for the reception of ashes or rubbish provided by section 881 lessens the temptation for small craft to dispose of their refuse illegally.

The very marked improvement in the condition of the waters of the lower bay and the beaches is largely due to the city's garbage being disposed of by reduction on Barren Island, 142,990 cubic yards having been disposed of in this manner during the past fiscal year, permits being issued by this office in accordance with law for the transportation of such material over the waters of the harbor, an average of 25 miles, and strict supervision being exercised by the patrol boats on duty to prevent loss of material in transit, due to improper trimming or careless handling.

The remainder of the city's waste material, consisting of street sweepings, ashes, etc., is still being disposed of at the mouth of the harbor, being deposited outside Sandy Hook light-ship. It was, however, confidently hoped that during the past fiscal year the city would dispose of this waste by placing it behind bulkheads on Riker's Island; but owing to delay in the construction of proper bulkheads or to legal formalities the city has been unable to begin operations up to this date. I understand, however, that the city has now invited proposals for the deposit of this material at that point, and will probably award the contract to the lowest bidder within the next few days. Unceasing vigilance will be required for some time by the boats of this office to prevent the illegal deposit of any of this material in transit, and to insure the deposit of the material in accordance with the permits.

The final disposition of the entire refuse of the city of Greater New York by reduction and behind bulkheads will prove of great benefit to the harbor.

The remainder of refuse material requiring close supervision consists of dredgings under private contract and débris from city improvements, technically known as cellar dirt. This duty devolves largely on the steam launches *Active* and *Alert* and the naphtha launch *Lookout*. The first two cover the North and East rivers, western end of Long Island Sound and Upper Bay, while the naphtha launch patrols the Kills, Princes and Newark bays, and tributary waters. These boats are useful in many ways in detecting and preventing violations of law. They are employed usually in the daytime, and at night when deemed advisable.

The cellar dirt is a fruitful source of trouble and complaint. It contains more or less floatable refuse, and its deposit is outside the light-ship, which is deemed as far from the coast as the type of boats used for the transportation of the material can venture with safety. Although

The following is an estimate of appropriation required for service of the fiscal year ending June 30, 1900, by the supervisor of the harbor of New York:

Detailed objects of expenditure, and explanations.	Estimated amount that will be required for each object.	Amount appropriated for fiscal year ending June 30, 1899.
Prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City:		
For pay of inspectors, deputy inspectors, office force, and expenses of office	$10,260.00	$10,260.00
For pay of crews and maintenance of 4 steam tugs and 3 launches	48,740.00	48,740.00
For new boiler and installing same in steam tug Nimrod	6,500.00	.....
For the purchase or construction of one steam tug	45,000.00	.....
Total	110,500.00	59,000.00

Very respectfully, your obedient servant,

N. J. K. PATCH,
Lieut. Commander, U. S. Navy, Supervisor.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

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